# International Library of Technology

380

A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN ENGINEERING PROFESSIONS, TRADES, AND VOCATIONAL OCCUPATIONS OR FOR THOSE WHO DESIRE INFORMATION CONCERNING THEM. FULLY ILLUSTRATED

GAS MAKING
GAS SUPPLY AND DISTRIBUTION
DOMESTIC USES OF GAS
PLUMBING TOOLS AND MATERIALS
SOLDERING AND WIPING

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# PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed.

International Textbook Company

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# CONTENTS

NOTE.—This volume is made up of a number of separate Sections, the page numbers of which usually begin with 1. To enable the reader to distinguish between the different Sections, each one is designated by a number preceded by a Section mark (§), which appears at the top of each page, opposite the page number. In this list of contents, the Section number is given following the title of the Section, and under each title appears a full synopsis of the subjects treated. This table of contents will enable the reader to find readily any topic covered.

## GAS SUPPLY AND DISTRIBUTION
*(Continued)*



## DOMESTIC USES OF GAS, § 14

## PLUMBING TOOLS AND MATERIALS, § 15



## SOLDERING AND WIPING, § 16

# GAS MAKING

## INTRODUCTION

**1.** The use of gas for fuel and illumination has increased enormously within the last decade, and there is a general tendency among manufacturers and domestic users to employ gaseous fuel in preference to coal whenever practicable.

The advantages of gaseous fuel over all forms of solid fuel, in the way of convenience and freedom from dirt, are so great that its use is likely to become universal. It is now used for a great variety of mechanical and other manufacturing operations, ranging from the delicate work of tempering hair springs for watches to the gigantic operations of glass melting and steel making. In dwellings, it is used to great advantage for cooking, ironing, drying, heating water, and in recent years has been used successfully for house warming. For direct heating, it is burned in gas stoves and fireplaces, and, for hot-water or hot-air heating, it is used in specially designed boilers and furnaces.

One of the circumstances that tend to increase the general use of gas is the readiness with which it can, by means of suitable gas engines, be used to generate power. These motors are made in all sizes, from mere toys to engines of 500 horsepower; and, owing to their great convenience and remarkable economy, their use is likely to become general.

**2.** Until recent years only one kind of gas was used for illuminating and heating purposes, and that was obtained by

the distillation of bituminous coal. The demand for gas for heating purposes, however, became so great, that new processes were invented, and other varieties of gas have been introduced, so that now all forms of gaseous fuel are called by the general name of gas. The kinds of gas now commonly used are as follows: *Coal gas*, *oil gas*, *water gas*, *producer gas*, *natural gas*, *gasoline gas*, or carbureted air, *Blau gas*, and *acetylene*.

## MANUFACTURE OF GAS

### COAL GAS

#### GENERAL DISCUSSION

**3.** Coal gas is produced by the destructive distillation of bituminous coal in ovens or retorts. These are as nearly as possible air-tight and are heated externally by a furnace. A very simple experiment that may be used to illustrate the production of coal gas in a crude way is as follows: Take an ordinary clay pipe and nearly fill the bowl with soft coal such as blacksmiths use; close the mouth of the bowl with damp clay and place the pipe in a fireplace or stove in such a way that while the bowl is in the fire the stem will be outside. In a short time coal gas will begin to issue from the small hole in the stem, and on being lighted this gas will burn with a bright flame in a manner similar to ordinary illuminating gas.

**4. Composition.**—Coal gas is not a simple gas but a mixture of a number of gases, the quantity of each one present in a given volume of coal gas varying somewhat, according to the kind of coal used and the temperature at which it is carbonized.

The composition of coal gas can only be determined exactly by analysis. Gas fitters are not required to do such work. It is usually done by the gas manufacturers or chemists.

The following may be considered to be about the average results found by a volumetric analysis:

| | Per Cent. |
|---|---|
| Hydrocarbon vapors | .6 |
| Carbon dioxide | 3.4 |
| Heavy hydrocarbons | 4.4 |
| Oxygen | .3 |
| Carbon monoxide | 10.1 |
| Hydrogen | 45.9 |
| Marsh gas | 30.6 |
| Nitrogen | 4.7 |
| | 100.0 |

The above is an analysis of purified gas from which the carbon dioxide has not been removed.

**5. Impurities.**—In the unpurified state, coal gas also contains ammonia, sulphureted hydrogen, and a small percentage of other compounds, mainly carbon bisulphide. Of these impurities, the two former must always be removed; but the amount of carbon bisulphide present is so small that in most American works no attempt is made to remove that which escapes with the gas after it has passed through the washer. When the gas is driven out of the coal by heat, it contains a certain proportion of hydrocarbons that are volatile only at a high heat; these begin to condense as soon as the gas begins to cool, forming tar. The non-volatile part of the coal, which remains when all the gas has been driven off, is called coke. In addition to this, some of the hydrocarbons attach themselves to the hot walls of the retorts, forming retort carbon, which must be removed at intervals of from 2 weeks to 2 or 3 months, according to the conditions under which the retorts are operated. The length of time required to drive the gas entirely from the coal varies according to the heat to which it is subjected, less time being required as the temperature of the retort is raised.

It is now almost the universal custom to keep the retorts at a temperature high enough to drive off the gas in about 4 hours. Under these conditions a long ton, or 2,240 pounds,

of good gas coal should produce about 10,000 cubic feet of about 17-candlepower gas, about 1,400 pounds of coke, 12 gallons of tar, and 4 pounds of ammonia. With coal of inferior quality, however, these figures might be very different.

The term **candlepower of a gas** defines its light-giving quality. It is measured while the gas is burning in an open burner at the rate of 5 cubic feet per hour by comparing the light emitted with that of a standard candle, which is one that burns 120 grains of spermaceti per hour.

**6. Enriching Gas.**—In many works, coal gas is enriched to over 20 candlepower either by mixing water gas with it or by the use of oil or cannel coal. This coal yields gas of high illuminating value, but the coke from it is of poor quality.

**7. Gas Coal.**—In order to get the best results from gas coal, it should be broken into lumps from 2 to 3 inches square and should be as free as possible from slack. The following is an analysis of good gas coal:

| | Per Cent. |
|---|---|
| Volatile matter | 36.00 |
| Fixed carbon | 57.96 |
| Water | 1.51 |
| Sulphur | .93 |
| Ash | 3.60 |
| | 100.00 |

**8. Specific Gravity and Odor of Coal Gas.**—Ordinary coal gas has a specific gravity of about .45, air being taken as unity. It yields about 650 British thermal units per cubic foot.

The well-known pungent odor of coal gas is due mainly to the olefiant gas, which is composed of what is known as the heavy hydrocarbons.

## BY-PRODUCTS

**9.** The by-products of coal-gas manufacture are coke, tar, and ammonia.

**10.** Gas coke is not hard enough for blast-furnace work, but it makes an excellent domestic fuel, as it burns freely

with a light draft, gives no smoke, and is clean to handle. Most gas companies find a ready market for all the coke that is not used about the works. Coke is frequently sold by the bushel instead of by weight. It weighs from 23 to 32 pounds per cubic foot, and from 35 to 42 pounds per heaped bushel; the average is about 38 pounds.

**11.** In the early history of gas manufacture there was little demand for tar, and it was frequently allowed to run to waste or was burned, but modern chemistry has developed the fact that coal tar is a very complex substance, containing more than 600 different products, among which are many different kinds of coloring matters and chemicals of commercial value. Tar is also of considerable value as a fuel and is sometimes used as such in the gasworks. It is usually sold by the gallon.

**12.** Ammonia is produced during the carbonization of coal by the union of hydrogen and nitrogen. It is readily absorbed by water, which will take up about 700 times its own volume of ammonia gas, at a temperature of 60° F. As the temperature of water is raised, it rapidly loses its power of absorbing ammonia and at 180° no ammonia can be absorbed. Ammonia is always removed from gas by allowing the gas to come in contact with water, the supply of which is usually so regulated that a weak ammoniacal liquor of about 2° specific gravity, as shown by a Twaddle hydrometer, is produced. This is usually distilled at the works and either ammonium sulphate or crude ammoniacal liquor, which is from 15 to 20 per cent. ammonia, by weight, is produced. It is then sold on the basis of the number of pounds of ammonia in the material.

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## COAL-GAS PLANT

**13. Retorts.**—In Fig. 1 is shown the general appearance of a bench of retorts. The retorts *a* are heated by means of a fire on the grate *l*. From *a*, the gas passes up through the stand pipes *b* and through the hydraulic main *e*, where the greater part of the tar and water vapor is removed. Each

pipe *b* curves downwards on entering *e* and has its mouth below the surface of the tar and ammonia contained in *e*. An effectual seal is thus formed and the gas is prevented from flowing back to the retorts when they are opened for charging. The surplus tar and water flows off through the pipe *h* to the tar well. From the hydraulic main, the gas passes through pipes *c* to an exhauster, or pump, and thence to the condenser.

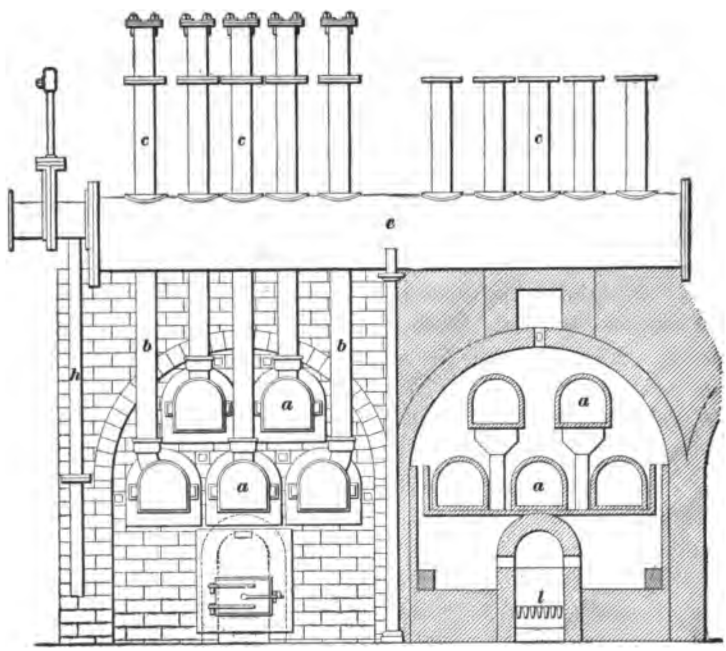


Fig. 1

**14. General Arrangement.**—A general idea of an entire plant may be obtained from Fig. 2, in which the exhauster and station meter are omitted. The station meter is a large device used for measuring the gas and is placed between the purifier and the gas holder. The exhauster is placed between the condenser and the scrubber to avoid back pressure in the retorts. The gas passes from the hydraulic main *e* through *c*, and down *d* to the condenser *f*, where the gas is compelled to pass through the curved pipes. These pipes are sometimes

cooled by the atmosphere, in which case the number of pipes must be very large. In others, the pipes are surrounded by water, and the number of pipes can be made very much less than when cooled by air. After passing through *f*, and leaving the remainder of the tar water behind in the base of the condenser, from whence the overflow passes out through the bent pipe *i*, the gas goes to the scrubber *g*. There it passes over large wet surfaces, such as coke or small wood brush. Should any of the tar remain, after passing through the con-

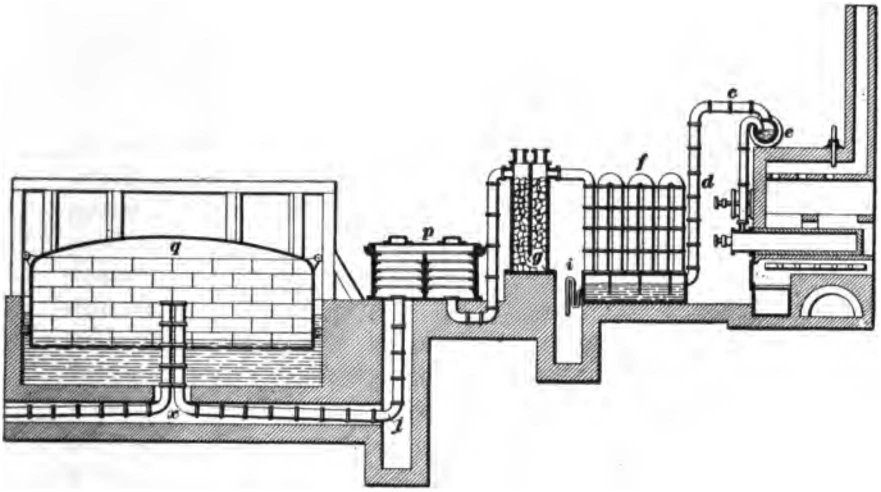


FIG. 2

denser, it is deposited in the scrubber. Only a small part of the ammonia is carried past.

The gas still contains some sulphur compounds and carbon dioxide. To free it from these substances, the gas next goes to the purifier *p*, where it passes through trays of dry or slightly dampened lime, which removes most of the impurities, and the gas, now ready for use, flows through *l* to the gas holder *q*, where it is stored. From *q* it passes through *x* to the station meter and pressure governor and thence to the gas mains. From the main the gas flows into the house service pipes of the consumers.

## WATER GAS

### GENERAL DISCUSSION

**15. Composition.**—Water gas is a mixture of hydrogen and carbon monoxide. It is made commercially by the contact of steam with incandescent carbon in the form of anthracite coal or coke. The steam is decomposed, the hydrogen being separated from the oxygen. The oxygen takes up carbon from the coal or coke, and forms carbon monoxide as well as a small quantity of carbon dioxide. The resultant gases from the contact of steam with incandescent carbon are then mainly hydrogen and carbon monoxide, chemically separate but mechanically mixed together. This is what is called *blue*, or *uncarbureted*, water gas. It burns with a non-luminous flame and is consequently useless for lighting purposes except in incandescent lamps of the Welsbach type. In actual practice, this water gas is always enriched with oil gas, which furnishes the hydrocarbons necessary to make a luminous flame. The oil gas was made separately in many of the older forms of apparatus, but it is now commonly produced in the same machine in which the water gas is made.

**16. Impurity.**—The only impurity found in water gas, which must be removed, is sulphureted hydrogen, which is formed from the sulphur always present in greater or less quantity in the coal or coke and sometimes in the oil. The sulphureted hydrogen is removed by purification with lime or iron oxide, in the same way that the purification of coal gas is accomplished.

Carbon dioxide, which is formed by either imperfect contact of the steam with the incandescent carbon, or because the temperature of the carbon is too low, is not a dangerous impurity; it is merely an inert gas, incapable of combustion. However, it absorbs heat when the gas is burned and consequently reduces the heating and lighting power. It can be removed by purification with lime, but purification is unnecessary if the generating apparatus is handled properly.

**17. Analysis.**—The following is a volumetric analysis of a sample of purified water gas:

| | Per Cent. |
|---|---|
| Hydrocarbon vapors | 1.2 |
| Carbon dioxide | 3.0 |
| Heavy hydrocarbons | 12.6 |
| Oxygen | .4 |
| Carbon monoxide | 28.0 |
| Hydrogen | 31.4 |
| Methane | 20.2 |
| Nitrogen | 3.2 |
| | 100.0 |

**18. Coal and Oil Required.**—Water gas requires from 30 to 40 pounds of coal or coke per 1,000 cubic feet of gas made, and from 4 to 5 gallons of oil, depending on the candlepower required. Usually between 5 and 6 candlepower is obtained from each gallon of oil used. There are about 300 heat units yielded per cubic foot of uncarbureted water gas, and about 625 heat units are yielded by 24-candlepower carbureted water gas. The specific gravity of 24-candlepower water gas is about .625, air being taken as unity.

Pure uncarbureted gas has no perceptible odor, but the carbureted gas has an odor fully as strong as coal gas. This is mainly due to the hydrocarbons from the oil that is used for enriching.

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## WATER-GAS MACHINES

**19.** Almost all the water-gas machines now in use are modifications of the Lowe type, which consists of a generator, where the blue water gas is produced, and a superheater, or a carbureter and a superheater, where the oil is vaporized and mixed with the blue water gas. The generator is a circular steel sheet, the height of which is about one and one-half times the diameter. It is lined with a double lining of firebrick blocks and is provided with grate bars at the lower end and with air-tight doors at the top, where the coal is charged in, and at the bottom, where the clinkers are taken

out. There are also connections for the escape of the gas and for the proper supply of steam and air. The capacity of any generator depends largely on the grate area and may be figured at a minimum of 20,000 cubic feet of gas per square foot of grate surface per 24 hours.

**20.** An example of a water-gas plant is given in Fig. 3. The generator *a* is first filled to the height shown in the figure with clean anthracite, egg size. The coal is fed through *p*, from the second floor, where it is stored. The coal in the generator is ignited, and is raised to a very high temperature by means of an air blast. The gases passing through the pipe *f* in the direction of the arrows again meet with an air blast at *g*, which blows them in a hot flame through the superheater *t* and out through the valve *h* to the smokestack. The body of the superheater is filled with loose firebricks, which take up the heat from the passing gases.

On the bricks becoming sufficiently heated, the air blast is shut off, the valve *h* is closed, and steam at a very high temperature enters through the pipe *e*. Coming in contact with the white-hot coal, the oxygen and hydrogen separate, forming water gas with the carbon of the coal. This gas passes through the superheater, where any steam remaining is further broken up, and flowing out through *n* passes through the washer to the scrubber *y*, and thence to the condensing apparatus.

The water gas, as it now is, burns with a pale-blue flame, giving little or no light, unless it is burned in connection with a gas mantle. On this account it is necessary, in order to make the gas a good light giver, to add some hydrocarbon. For this purpose oil is allowed to flow in a fine stream into the generator from the reservoir *m*, during the passage of the steam. These hydrocarbons make the gas flame white, so that it can be used in an open burner. Water gas, properly treated in this way, gives a much brighter flame than coal gas. The hydrocarbons are often added after the gas is purified; they are not needed, however, when the gas is to be used for heating purposes or for gas engines.

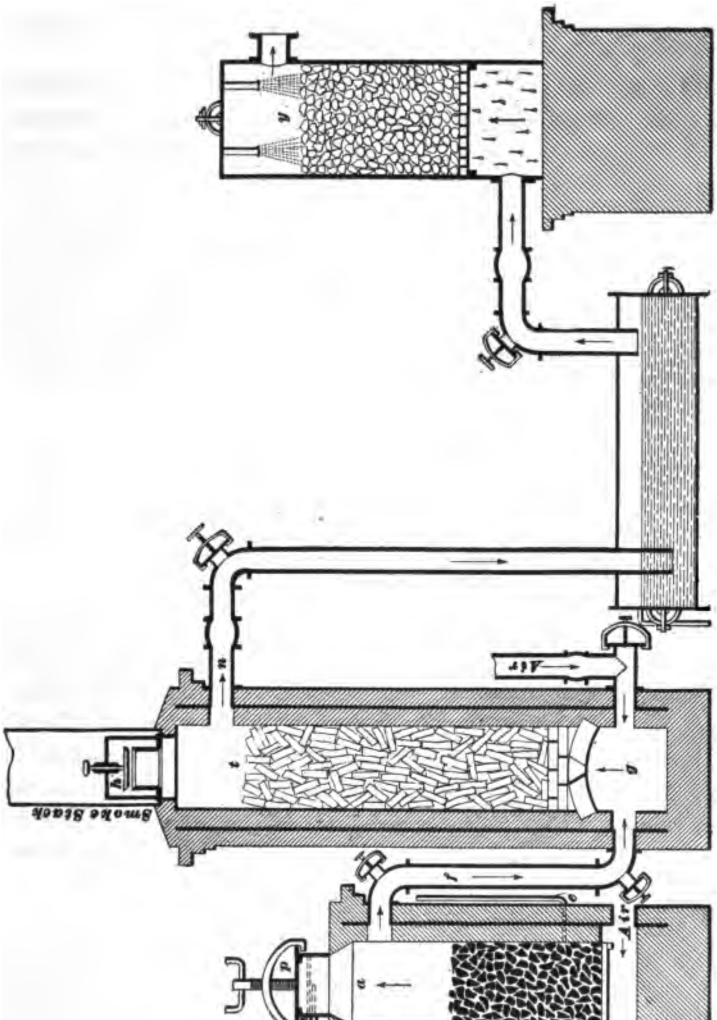


FIG. 3

### ARCHER GAS

**21.** Archer gas is water gas made from crude petroleum by a continuous process; it derives its name from the inventor of the apparatus. The oil is pumped in a small stream into a red-hot retort, where it is quickly reduced to vapor by the heat. The oil vapor is then mixed with a current of superheated steam and the mixture is driven through a long coil of very hot pipe. The oxygen of the steam unites with the carbon of the oil, forming carbon monoxide, and the hydrogen is set free. The resulting gas is permanent and is of high value for heating purposes. It is produced at a pressure of from 8 to 10 pounds per square inch.

## OIL GAS

### PROCESS

**22.** Oil gas is made, in much the same manner as coal gas, by the process known as destructive distillation. This process consists in heating the oil to a very high temperature and causing the heavy hydrocarbons it contains to break up into the lighter or gaseous forms. In the manufacture of this gas, not only is petroleum utilized, but many animal and vegetable fats and oils are used as well; among these are to be found the waste fats that occur in the manufacture of woolens, and ordinary resin.

### OIL-GAS PLANT

**23.** An example of an oil-gas plant is given in Fig. 4. From the oil-supply tank *l*, oil is allowed to flow into the pipe *p*, which has the form ᔕ in order that some of the oil may remain in the curve and prevent the gas from escaping through the pipe *p*. The retort *b* is kept at a bright-red heat, in order that, as soon as the oil strikes it, it may become gasified; the gas then passes out through the hydraulic main *e*

to the combined scrubber and condenser *g* and the purifier *i*. Oil gas is used extensively in lighting railroad trains, under the Pintsch system.

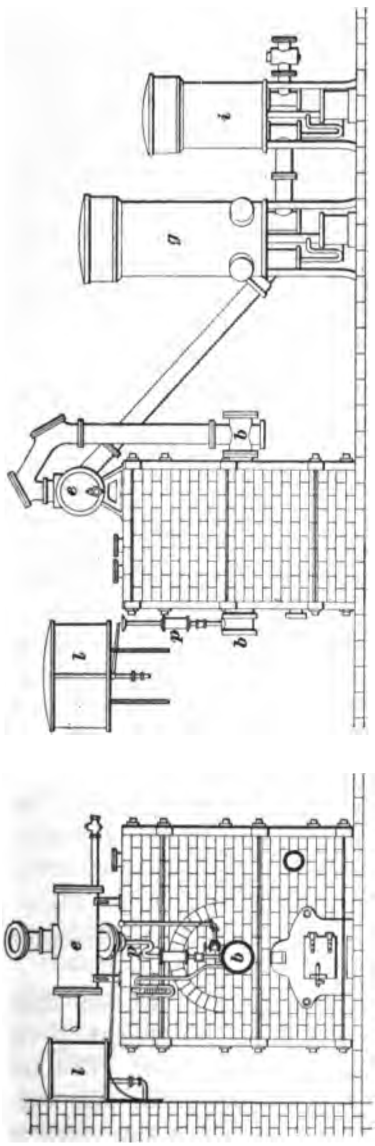

FIG. 4

## PRODUCER GAS

### PROCESS

**24.** Producer gas, properly so called, is made without the aid of water in the generator. It is, in fact, nothing more than the products of incomplete combustion of the fuel used. The average quality of producer gas contains from 10 to 15 per cent. of hydrogen, and from 20 to 30 per cent. of carbon monoxide. These constitute the combustible part of the gas, nitrogen forming about 40 to 60 per cent. of the total volume. This gas burns with a dull reddish flame and its value for heating purposes is about one-fourth that of an equal volume of good coal gas.

**Semi-water gas** is a combination of water and producer gas, which, although containing less nitrogen and a larger percentage of carbon monoxide and hydrogen than producer gas, is made by a continuous process.

#### GENERATION

**25.** The generator *a*, Fig. 3, is connected directly to the washer. The air blast being on, the gas is allowed to pass directly through *f* to the washer. Then, if the air supply is properly regulated, the carbon of the fuel burns to carbon monoxide, a highly inflammable gas; the nitrogen of the air is carried with the gas, and the result is a mixture of carbon monoxide, carbon dioxide, and nitrogen, together with small quantities of marsh gas and hydrogen that were originally combined with the carbon in the coal. Nitrogen forming, as it does, four-fifths of the atmosphere, must necessarily be present in a large quantity. This gas will neither burn nor assist in burning, but as it takes up room and carries off heat, is a nuisance, particularly when the gas is used in the gas engine. More than one-half, usually about six-tenths, of the volume of producer gas consists of nitrogen. As this gas cannot be gotten rid of by any inexpensive process, the value of producer gas for gas-engine use is not very great. It can be used with profit, however, where the gas would otherwise be wasted, as when made in the manufacture of pig iron, or where the gas is made from very cheap coal refuse, as culm. The manufacture of producer gas, being a continuous process, has led to the invention of the modern, so-called producer-gas processes, in which water plays an important part.

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## ACETYLENE GAS

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#### GENERAL DISCUSSION

**26.** Acetylene is a pure hydrocarbon gas; it is represented by the chemical formula $C_2H_2$.

Acetylene contains a higher percentage of carbon than any other hydrocarbon, the composition by weight being 92.3 per cent. carbon and 7.7 per cent. hydrogen. The gas is colorless and the commercial article has a strong odor suggestive of garlic. This odor is mainly due to the presence of small quantities of various impurities; where these are not

present there is only a slight, and by no means disagreeable, ethereal smell. Acetylene is very readily soluble in water. At ordinary temperatures, 12 cubic feet of water will absorb about 13 cubic feet of acetylene. The specific gravity is .91, air being taken as unity. In burning 1 cubic foot of acetylene, 1,385 heat units are developed. Acetylene burns with almost perfect combustion and no smell is noticeable from the burners. Where an odor of acetylene is discernible, it is an evidence that there is a leak. Acetylene gives a clear white light very similar to sunlight, and all substances show their true colors when illuminated by it.

The candlepower, under the most favorable conditions, is about 240 for a consumption of 5 cubic feet per hour; but it must be noted that it is impossible to get economical results with a flame giving more than 50 candlepower.

Acetylene is usually burned through half-foot burners, that is, burners that burn ½ cubic foot of gas per hour, each burner yielding in ordinary practice about 20 candlepower. Where more light is desired in one place several such burners are grouped together.

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### PRODUCTION

**27.** Acetylene is produced commercially by adding water to a substance known as calcium carbide, which is a stone-like material, usually dark brown or black in color. It cannot be burned and will keep indefinitely if kept sealed from the air. If left exposed, the moisture in the atmosphere gradually slakes it and it eventually turns to slaked lime. It always gives off an acetylene odor, due to the fact that the moisture in the air is constantly decomposing it and producing small quantities of acetylene.

Calcium carbide is produced by fusing together carbon, in the form of ground coke and lime, in the intense heat of an electric furnace.

When calcium carbide is reacted on by water, slaked lime and acetylene is produced according to the following equation:

$$\underset{\text{carbide}}{CaC_2}+\underset{\text{water}}{2H_2O}=\underset{\text{slaked lime}}{Ca(OH)_2}+\underset{\text{acetylene}}{C_2H_2}$$

One pound of absolutely pure calcium carbide will produce about 5.5 cubic feet of acetylene; but carbide as usually sold is not pure, and the yield of acetylene will be 5 cubic feet, or less, per pound of carbide.

**28.** The impurities found in calcium carbide, and consequently in acetylene, are phosphorus, sulphur, ammonia, and traces of hydrogen and silicon hydride. Any unfused carbon and the ash from the coke that may be present in the calcium carbide will be found in the residue of slaked lime after the gas has been driven off.

The phosphorus and sulphur, in the form of phosphureted hydrogen and sulphureted hydrogen, are the only impurities that might prove objectionable, but where good carbide is used the quantities of these impurities are so small that they may be neglected.

**29.** The ammonia and sulphureted hydrogen may be largely removed by the washing that the gas gets in a carbide-feed generator as it bubbles up through the water, or in the case of a water-feed generator, by making the gas bubble through a washer after it is generated. Any considerable quantity of phosphureted hydrogen in acetylene will cause burner stoppage and the production of a kind of white haze, which is also produced when acetylene is burned where the ventilation is poor, as in store windows. When it is necessary to remove the phosphureted hydrogen, it can be done by passing the gas through a chemical scrubber containing some oxidizing agent, such as chromic acid, or through chloride of lime. The latter is perhaps the most efficient purifying agent, but it is difficult to use because it has a tendency to lump together when moist and prevent the easy passage of gas. A substance known as puratylene, which does the work excellently, has, however, been invented. It is a mixture of chloride of lime with other lime salts and is produced in a porous, lumpy state. It causes but little resistance to the passage of gas, and removes not only all the phosphureted hydrogen but also the water vapor, so that the condensation of water in the pipes is avoided. The vessel that contains it

is usually placed at the outlet of the gasometer or storage tank, so that the gas after passing through it does not come in contact with any more water but goes directly into the pipes for use. The purifying vessel is usually a small cylindrical tank that is partly filled with the purifying material. The gas is usually passed in at the top of this vessel and out at the bottom.

**30.** In the production of acetylene, a large amount of heat is generated. This heat may be localized so as to be harmful to the acetylene produced, or it may be diffused so as to do no harm, according to the way the water and acetylene are brought together.

Thus, if water is allowed to drip slowly on a mass of carbide, local overheating will occur and the acetylene may be partly broken up into other hydrocarbon compounds of an oily nature; the candlepower will be much reduced thereby and there will be a tendency for the burners to clog and carbonize.

**31.** Carbide, when heated, has a tendency to give off lime dust, which will choke the burners and may even fill the pipes up completely with a deposit of lime. This trouble may be partly overcome by the use of filters of cotton or thin cloth, or by making the acetylene bubble through a washer. When the carbide is dropped in small lumps into a considerable volume of water, the water absorbs the heat and the gas bubbles out of the water, cool and free from dust.

**32.** The sludge of lime waste that is left after all the acetylene has been evolved should be of a whitish color; if yellow or brown, it is a sure indication that the heat has been too high. This residue is harmless and will not burn. It packs well and makes good walks or drives, and as it consists mostly of the hydrate and carbonate of lime, it is valuable as a fertilizer.

**33.** If acetylene is compressed, so that the particles of gas are forced together closer, by a pressure of 150 pounds or more, to the square inch, it may be decomposed when

subjected to high temperature and may become violently explosive. The use or possession of liquid acetylene or of acetylene at high pressure is dangerous and should be avoided, but acetylene at ordinary temperatures cannot be exploded, unless it is mixed with air and ignited. If subjected to high temperature at ordinary pressure, without the presence of air, it will merely decompose into other hydrocarbon forms, such as benzine, methane, etc.

**34.** Acetylene, in common with all other combustible gases, is explosive when mixed with air in certain proportions. One part of acetylene mixed with 12.5 parts of air will produce perfect combustion and most violent explosion, but an admixture of from .03 to .82 parts of air will also explode with violence. Moreover, the igniting temperature of acetylene is comparatively low. While ordinary coal gas ignites at about 1,100° F., the ignition point of acetylene is about 900° F., and it may therefore be lighted by a cigar or cigarette. It will readily be seen from the foregoing statement that acetylene must be handled with care; but as a mixture of 1 part of acetylene in 10,000 parts of air may be readily detected by the smell, leaks may be located and stopped long before there is danger of an explosion.

It is dangerous, however, to look for leaks with a match or candle, and all tests should be made with a little soap and water. The soapsuds should be brushed on wherever a leak is suspected; the formation of soap bubbles will indicate its location.

**35.** With properly installed piping and a properly constructed and placed generator, there is absolutely no danger in the production of acetylene in the cellars or other suitable parts of residences, provided the apparatus is handled by a person who has been properly instructed, and provided good judgment is used. This is made evident by the fact that the fire underwriters make no objection to the installation of any one of the numerous generators that have been tested and approved by their experts, and are installed in accordance with the requirements of local laws or ordinances.

## GENERATORS

**36. Types.**—There are five general types of generators in use; viz.: the *spray type*, the *overflow type*, the *recession type*, the *dip type*, and the *drop*, or *plunge*, *type*.

**37.** The **spray generator** is shown in Fig. 5. It consists of a drum, or shell, *a*, either cylindrical or square, into which a pan *b* of carbide is introduced through a removable head *c*. Water from a spray tube *d* is allowed to drip on this carbide, as shown, the supply being usually cut off automatically by the increase in pressure of the gas in the generator,

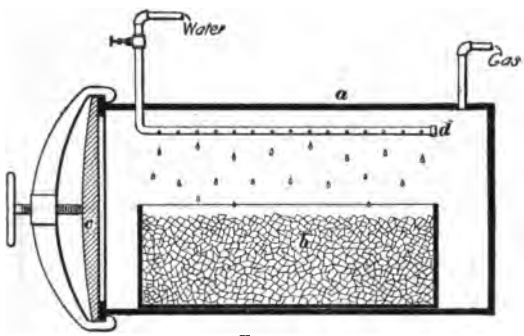

FIG. 5

or by the raising of the bell of a small gas holder when gas is produced more rapidly than it is required.

Spray generators are likely to overheat the gas, and this causes a loss of candlepower and the choking of the burners. Steam is frequently generated when the water strikes the carbide and lime dust is thrown off; this clogs the pipes and burners. The spray generator is of two kinds, the *dry* and the *wet*. In the first form only enough water is added to produce the gas, the residue being removed in a dry state. This form is wasteful, because some of the carbide is frequently removed unused, and the unused carbide is sure to give the residue a very strong odor. In the wet machines enough water is run in to flood the carbide before it is removed.

**38.** On account of the overheating and the trouble from lime dust, the spray type of generator is suitable only for

special conditions, such as occur in bicycle lamps, where the spray or drip system is the only practical way to apply the water to the carbide.

**39.** In the **overflow generator,** shown in Fig. 6, the carbide pan is divided into a number of small compartments so arranged that when water is turned into the first compartment it floods the carbide in that before it overflows and begins the generation of gas in the second. The compartments are thus successively filled and overflowed, until the carbide has all been flooded. The water feed may be automatically regulated by the gas pressure or by a mechanism on the gas holder.

Generators of this type are open to the same objections as those of the spray type, though perhaps to a smaller degree. Some of them give very fair results in practical use.

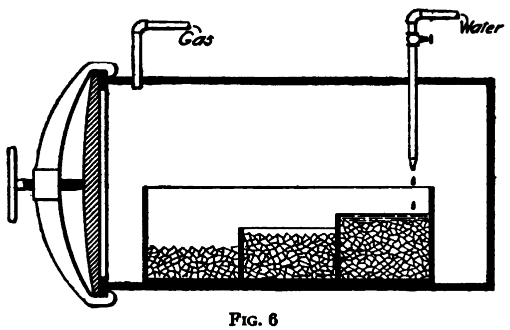


Fig. 6

**40.** In the **recession generator,** shown in Fig. 7, the carbide is held suspended in baskets or perforated pans *a*, and water is allowed to rise in the generator until it reaches the carbide, when the production of acetylene begins. Should gas be produced faster than it is needed, the pressure forces the water down, away from the carbide, and back through the water-supply pipe *b*, when generation ceases. The water and residue are drained off through a drain pipe provided with a cock *c*, or valve, at the bottom of the generator. If the water comes up to the carbide, produces vigorous generation, and then quickly recedes, the carbide is apt to become so hot as to be incandescent, and great damage to the quality

of gas results. Different makes of generators vary in their tendency to cause this trouble.

**41.** In the **dip generator,** shown in Fig. 8, the carbide is placed in baskets or perforated pans *a*, which are suspended from the inside of the bell *b* of a small gas holder or gasometer. As gas is taken from the holder, it gradually lowers until the carbide comes in contact with the water in the tank. Acetylene is then generated, and if the rate of generation exceeds the demand, the gas accumulates under the bell and raises it until the carbide does not touch the water, when the generation of gas soon stops. The carbide in this generator is very apt to become overheated, just as in the recession apparatus.

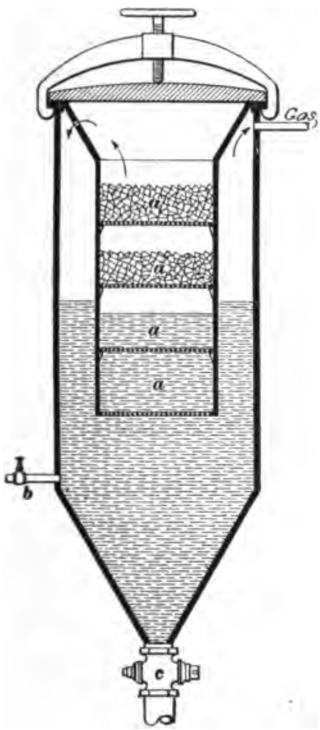


FIG. 7

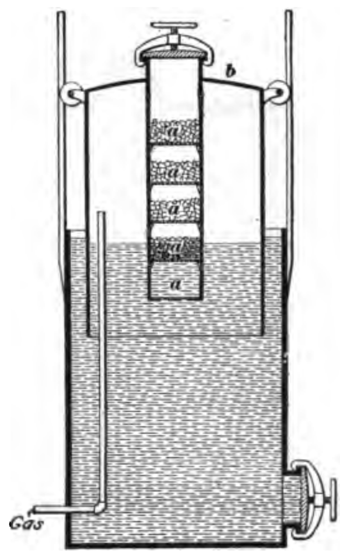


FIG. 8

**42.** In the **drop generator,** shown in Fig. 9, the carbide is allowed to fall, a small piece at a time, from a carbide chamber, as at *a*, into a large volume of water. Since the small

piece of carbide is dropped into a large quantity of water, the water absorbs the heat as fast as it is generated, so that the gas produced is cool, that is, below 212° F., and is consequently of excellent quality. As the gas bubbles up through the water it is thoroughly washed and a large proportion of the impurities are removed. The residue, or lime sludge, drops to the bottom, as at *b*, and is removed from time to time. It has been claimed that a considerable loss of acetylene results in this form of apparatus, since 1 cubic foot of water will absorb a little over 1 cubic foot of acetylene. This assertion is true if the gas has access to pure water, but as the water in the generator is constantly taking up lime, the gas absorbed when water is freshly added is largely driven out again and the acetylene loss is very slight.

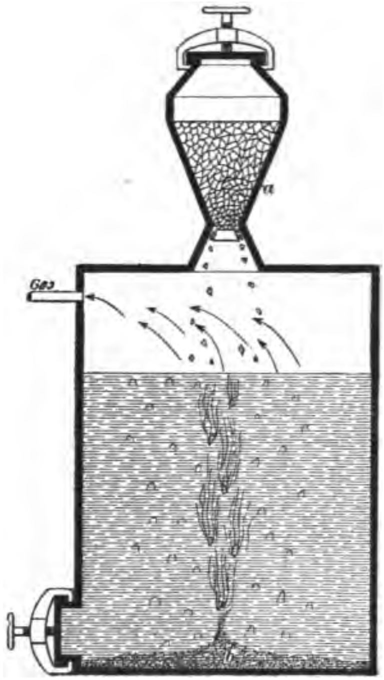

FIG. 9

In theory, the quantity of water required to produce all the acetylene from 1 pound of carbide is .56 pound, or a little over $\frac{1}{2}$ pint, but 1 gallon to the pound is nearer the usual practice.

**43.** The granulated carbide is fed into the drop type generator either by hand or automatically. The former method is suitable for large establishments and public lighting plants, where considerable holder capacity is at hand and where an attendant can give regular attention to the feeding.

In the early history of acetylene lighting, great difficulty was encountered in constructing an apparatus that would successfully feed granulated carbide automatically.

**44. Gas Holder, or Storage Tank.**—All generators should be provided with a storage tank of the gas-holder type to take up and store the gas that generates after the flow from the machine has been cut off. The storage tank prevents an undue pressure in the generator due to this after generation.

**45.** The gas holder shown in Fig. 10 is considered to be the best storage tank, because it not only serves to store the gas, but also acts as a pressure regulator and maintains a constant pressure in the piping system. Gas enters the gas holder from the generator through *a* and flows up an inner tube *b* to the space under the floating bell *c*; it then flows down through another inner tube *d* to the gas service pipes. The bell rises and falls in the water, thus changing its gas-holding space to suit changes in the volume of gas delivered by the generator without materially changing the pressure in the gas pipes. The water at *e* serves as a seal for the mouth of *a*, while the base of *d* extends into *e* to act as an overflow for the lower chamber. The rod *f* is a guide for the bell.

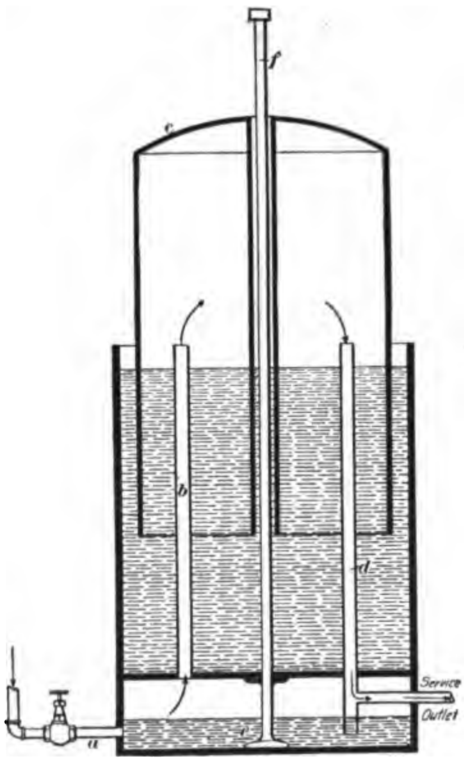

FIG. 10

**46.** Another form of storage apparatus consists of two tanks that are connected at the bottom and partly filled with water, the top of one being open to the atmosphere. When

gas is admitted above the water in the closed tank, the pressure of the gas forces down the water in that tank and correspondingly up in the other tank. This apparatus has the disadvantage of a variable pressure, the pressure increasing as gas is added. Consequently, some form of a reducing valve must be placed on the outlet gas pipe in order to insure a steady pressure at the burners and hence steadiness of light.

**47. Safety Blow-Off.**—All generators should be provided with a safety valve, or seal, that will open at a pressure equivalent to 6 inches of water, and is connected with a pipe leading to the outside of the building. The safety valve, or seal, is intended to prevent an excess of pressure in the generator.

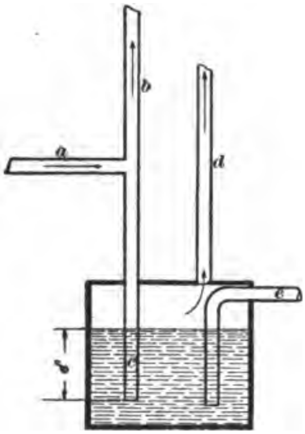


FIG. 11

As no mechanical blow-off valve will work properly at the low pressures usually employed in gas lighting, the best blow-off is formed by a piece of piping dipping 6 inches into a water seal. Such a seal will reseal itself when the pressure goes down.

Fig. 11 shows the operation of such a seal. The gas pipe *a* connects the trap to the gas holder, or generator, but no valve or shut-off cocks must be placed between this trap and the generator. The gas passes up through *b* to the gas fixtures. When the pressure in *a* becomes great enough, gas blows down through *c*, rises through the water in the trap, and blows to the atmosphere through *d*. The pipe *e* is an overflow to prevent the trap from filling with water and thus increasing the resistance to a blow-off.

Care should be exercised to see that the trap always contains sufficient water. The outlet pipe *d* should never project down far enough to enter the water, since water will then be forced up into *d*, in consequence of which the pressure may run up high enough to force the water out of the trap. The pipe *e* should have a tee with a short vertical piece of pipe

at its highest point outside the trap, in order to prevent any siphonic action.

48. **Number of Lights.**—Generators should never be connected with a greater number of lights than they are designed to carry, and they should preferably be operated on a smaller number of lights than they are rated for by manufacturers, in order to insure safety.

49. **Overheating in Generators.**—Overheating is caused by overloading, and results in too rapid generation; this causes a breaking up of the acetylene into other hydrocarbons, such as acithracene, benzine, stybolene, etc.

50. **Requirements of a Good Generator.**—The following are the points on which judgment was passed in awarding medals to the acetylene generators at the Pan-American Exposition at Buffalo, New York, in 1901:

1. The contact of the carbide should be with the water; in other words, the machine should be of the drop type.
2. The carbide should be fed into the water in proportion to the consumption of gas.
3. The gas pressure at the point of delivery should remain practically constant, irrespective of the number of jets burning, or of the amount of carbide, or of gas, in the generator.
4. The pressure should be equal in all parts of the machine and should not exceed that exerted by a 6-inch column of water.
5. When the lights are turned out the generation of gas should cease.
6. The gas should be delivered to the burners clean, cool, and dry.
7. The heat of generation must not exceed 200° F.
8. When the generator is recharged there should be no escape of gas.
9. If the generator is left idle for a long period there should be no deterioration of the carbide.
10. The gas holder attached to the generator should be of ample capacity and made tight with a water seal.

11. The pressure in the service pipe should never exceed that of a 3-inch column of water, and provision must be made to blow off into the air at a pressure of 6 inches.

12. The water capacity of the generator must be at least 1 gallon of water to 1 pound of carbide.

13. There must be a convenient method of getting rid of the slaked carbide without escape of gas.

14. The generator must be entirely automatic in its action. That is to say, after it has been charged it must operate without attention until the carbide is entirely exhausted.

15. There should be a simple method of determining the quantity of unconsumed carbide in the generator at any time.

16. The generators should be so simple in operation that they can be tended by unskilled labor without danger of accident.

17. The various operations of discharging the refuse, filling with fresh water, putting in carbide, and starting the generator should be so arranged that it is impossible to do them in the wrong order.

18. The generators must be so arranged that there can be no possibility of mixing air with acetylene gas.

19. Generators must be built of substantial materials well adapted to their purpose.

20. Generators must be so constructed that an addition to the charge of carbide can be made at any time, without affecting the light.

Any generator that is built according to the preceding points may be considered excellent.

**51. Selecting a Machine.**—No machine should be installed that is not approved by the fire underwriters. This precaution is necessary to prevent the cancelation of fire-insurance policies on the property in which the machine is installed. The National Board of Fire Underwriters issues a list of acetylene-gas machines approved by them, a copy of which may be obtained from the board on application. The address of the board can be obtained from any reputable fire-insurance agent.

**52.** To intelligently select a good acetylene-gas machine, the Fire Underwriters' latest list of approved machines should first be secured, and the manufacturers' catalogues of these machines next obtained. The construction and operation of the different machines should then be carefully studied, in order to determine which most nearly meets the previously explained requirements of a good machine.

**53. Protection of Generators Against Frost.**—Since water is used in acetylene generators and gas holders, they should be installed in places where the temperature will not go below the freezing point. Where this is impossible, the water drawn from the generator with the residue should be allowed to stand in a tank or barrel until the lime has settled out of it. The clear water may then be put back in the machine and will not freeze at a temperature above zero. Ten per cent. of glycerine added to the water in a gas holder will prevent freezing under ordinary conditions. Stoves or fireplaces must never be permitted in the same room with the generator. The generator room may be safely heated by hot water or steam pipes.

**54. Cost of Acetylene.**—Calcium carbide varies somewhat in cost, being generally about 4 cents per pound delivered in small quantities on the consumers' premises. Since 1 pound of calcium carbide will produce at least $4\frac{1}{2}$ cubic feet of acetylene, the cost may be reckoned at a little less than 1 cent per cubic foot, assuming carbide to be 4 cents per pound. The cost, therefore, for each ordinary $\frac{1}{2}$-foot burner, will be $\frac{1}{2}$ cent per hour for a 20-candlepower flame. Ordinary city gas at $1.50 per thousand cubic feet costs $\frac{3}{4}$ cent for each open flame burning 5 cubic feet per hour. City gas is usually about 20 candlepower, so that it would require one 5-foot burner to give as much light as a $\frac{1}{2}$-foot acetylene burner. When used with Welsbach lights, however, city gas gives about 20 candlepower per cubic foot, so that a light burning the usual quantity of gas, about $3\frac{1}{2}$ cubic feet per hour, would produce about 70 candlepower at a cost of .525 cent per hour. This comparison of costs is useful.

## ACETYLENE BURNERS

**55. Plain Burners.**—Ordinary gas tips or burners cannot be used for acetylene gas, because with such burners an acetylene flame does not get an air supply sufficient for perfect combustion, and consequently smoke will be formed. Moreover, the tip soon becomes so hot that the acetylene is decomposed by the extreme heat, before it is burned, and the candlepower of the flame is lowered, while the tip itself soon becomes choked with soot and carbon, which are produced by the charring of some of the more condensible hydrocarbons.

**56.** A good acetylene burner is made in the form of a **Y**, as shown in Fig. 12. The small jets *a*, one from each branch of the **Y**, impinge on one another and form a flat flame *b*. The two jets are at right angles. Each jet is a miniature Bunsen burner, just enough air being drawn into the burner through the holes *c* to give smokeless combustion. The flame itself does not touch the tips, which, consequently, do not become overheated.

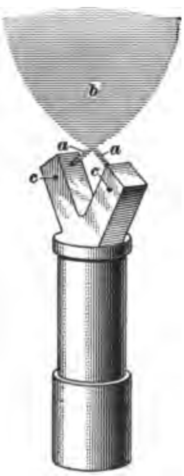

FIG. 12

**57.** As metal tips are apt to warp, even at the low temperature to which they are subjected, steatite tips are preferable.

**58.** It is bad policy to turn ordinary acetylene flames down, as the jets then lose their Bunsen effect and are apt to become clogged with soot. Burners that are supplied with a small needle valve regulating each jet may be regulated to burn a very small amount of acetylene with satisfactory results.

**59. Incandescent Burners.**—The use of acetylene in lamps of the Welsbach type has been frequently attempted and there are several such lamps on the market.

The highest practical efficiency obtained by the use of acetylene burners of the Welsbach type is about 90 candle-

power to the cubic foot; a ½-foot burner of this type would, therefore, give 45 candlepower, which is a little more than double the light that can be obtained by the open flame.

It has, however, been found that the intense heat is injurious to mantles, and if the use of Welsbach lights is to be made successful every trace of phosphureted hydrogen must be removed from the acetylene. Otherwise, phosphates of the earth of which mantles are composed are soon formed on the surface of the mantle and, as these phosphates are readily fusible, the life of the mantle is short.

**60. Cooking Burners.**—Acetylene cannot be used in gas stoves or ranges such as are ordinarily used for illuminating gas. Insufficient air supply from the ordinary stove Bunsen burner leads to the stoppage of the burner by soot and carbon, which is made worse by the heat of the burner decomposing the gas. In addition to this, the burner becomes hot and, in consequence of its low ignition temperature, the mixture of acetylene and air ignites below the burner.

Suitable burners, however, can be constructed. These have usually a long draft stack below the burner, so that a quantity of air sufficient for proper combustion is added and properly mixed with the acetylene; the area of the burner surface is arranged in such a proportion to the amount of gas to be consumed that the burner does not become hot enough at any point to cause flashing back. Stoves equipped with such burners are on the market, but their operation is much more expensive than that of ranges using ordinary illuminating gas. This is due to the fact that while acetylene gives ten times as much light, volume for volume, as ordinary illuminating gas, the number of heat units developed is only about threefold. Thus, a range burner consuming 15 cubic feet of illuminating gas per hour, at $1.50 per 1,000 cubic feet, costs 2¼ cents per hour, while an acetylene burner, to develop the same amount of heat, consumes 5 cubic feet per hour, which with acetylene at 1 cent per cubic foot, costs 5 cents. Where acetylene is at hand, however, the convenience of gaseous fuel will in many cases lead to the use of acetylene stoves.

**61. Acetylene Leakage.**—Leakage in an acetylene system is even more serious than in the case of illuminating gas. If an ordinary illuminating-gas company sending out 1,000,000 cubic feet per month has a leakage of 50,000 cubic feet in the same period, the leakage would be only 5 per cent.; but an acetylene gas company supplying the same amount of light would send out only one-tenth as much gas, or 100,000 cubic feet, and if the leakage remained the same, that is, 50,000 cubic feet, it would be 50 per cent.

**62. Acetylene Meters.**—Ordinary dry meters may be used for metering acetylene and should be rated at fifteen times their normal capacity. Thus a 3 light meter will supply 45 lights.

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### ACETYLENE FOR GAS-ENGINE USE

**63.** Gas engines may be operated by acetylene gas under suitable conditions, but, since the economy of a gas engine depends very largely on the degree of compression to which the mixture of gas and air in the cylinder is subjected before it is exploded, the economy of the acetylene gas engine must be less than that of the ordinary gas engine.

The compression of the charge in the engine generates heat, and consequently the compression in the cylinder of an acetylene-gas engine must be so low that the temperature of ignition will not be reached before the proper time for an explosion occurs. For the same reason the cylinder of the engine would have to be water-cooled sufficiently to keep the temperature always below the igniting point.

If, however, the same efficiency in relation to the comparative heating values of acetylene and illuminating gas could be obtained, the operation of the engine would be still more than twice as costly as with illuminating gas for the same reason that makes the use of acetylene stoves more expensive; 20 cubic feet of ordinary illuminating gas will develop 1 horsepower in a gas engine, which at $1.50 per thousand cubic feet costs 3 cents. An acetylene engine to develop 1 horsepower, according to the relative number of heat units, would use about 7 cubic feet of gas, which with acetylene at 1 cent per cubic

foot would cost 7 cents. On account of the low igniting temperature, it would be difficult to use a hot tube igniter on an acetylene-gas engine, but an electric igniter could be used.

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### ACETYLENE GASWORKS

**64.** In installing an acetylene gasworks it is best to put in a gas holder and a generator of such size that it will never be necessary to generate acetylene at night. A station meter, which may be of the ordinary dry type, should always be installed, as otherwise a careful record of the operation of the plant cannot be maintained. Automatic carbide-feed generators are sometimes used for such plants, but, as an attendant should always be at hand, the simpler hand-feed generators are more frequently used.

In this case the production of gas is somewhat intermittent, and a small relief holder should be installed to take up the fluctuation so that the gas passes through the meter at a regular rate of speed. The plant should be heated in winter by steam or hot-water coils, and the heater should be placed in a separate building away from the generator house.

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### ACETYLENE LAMPS

**65. Acetylene Street Lamps.**—Acetylene is very suitable for street lighting, as the flame is not easily blown out, but suitable globes and wind guards should be placed on all lamp posts.

On account of the compact generating apparatus that may be used, and the fact that a stock of carbide sufficient to produce a large amount of acetylene can be readily carried, acetylene is very suitable for the lighting of cars, boats, etc. Car lighting is also accomplished by means of acetylene carried under pressure in tanks in the same manner as Pintsch gas, but the dangers resultant from the use of acetylene in this way have prevented its general application. When such tanks are carried they should always be provided with fusible plugs, so that in case of fire the plugs will melt and the acetylene escape and burn, instead of exploding from overheating.

**66. Acetylene Portable Lamps.**—On account of the difficulty of proper regulation of the production of acetylene and consequent regulation of the pressure, portable lamps have not come into general use.

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### ACETYLENE-GAS MACHINES

**67. Rules and Requirements of the National Board of Fire Underwriters.**—The following rules and requirements regarding the construction, installation, and use of acetylene-gas machines, and for the storage of calcium carbide, as recommended by the Committee of Consulting Engineers, have been adopted by the National Board of Fire Underwriters. Attention is also called to the fact that the installation of acetylene-gas machines inside buildings is prohibited in certain districts by local authorities and local boards.

### PART 1

### Rules for the Installation and Use of Acetylene-Gas Generators

The use of liquid acetylene or gas generated therefrom is absolutely prohibited.

Failure to observe these rules is as liable to endanger life as property.

To secure the largest measure of safety to life and property, the following rules for the installation of acetylene gas machines must be observed:

### CLASS A

#### STATIONARY AUTOMATIC APPARATUS

1. *Foundations.*—(*a*) Where practicable to be of brick, stone, concrete, or iron. If necessarily of wood they shall be extra heavy, located in a dry place, and open to the circulation of air.

The ordinary board platform is not satisfactory. Wooden foundations shall be of heavy planking, joists or timbers, arranged so that the air will circulate around them and so as to form a firm base.

(*b*) To be so arranged that the machine will be level and unequal strain will not be placed on the generator or connections.

2. *Location.*—(*a*) Generators, especially in closely built-up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9.

(*b*) Generators to be so placed that the operating mechanism will have room for free and full play and can be adjusted without artificial light.

They must not be subject to interference by children or careless persons, and if for this purpose further enclosure is necessary it must be furnished by means of slatted partitions permitting the free circulation of air.

(*c*) Generators which from their construction are rendered inoperative during the process of recharging to be so located that they can be recharged without the aid of artificial light.

(*d*) Generators to be placed where water will not freeze.

3. *Escapes or Relief Pipes.*—Each generator to be provided with an escape or relief pipe of ample size; no such pipe to be less than $\frac{3}{4}$ inch internal diameter. This pipe to be substantially installed, without traps, and so that any condensation will drain back to the generator. It is to be carried to a suitable point outside the building and terminate in an approved hood located at least 12 feet above ground and remote from windows.

The hood is to be constructed in such a manner that it cannot be obstructed by rain, snow, ice, insects, or birds.

4. *Capacity.*—(*a*) To be sufficient to furnish gas continuously for the maximum lighting period to all lights installed. A lighting period of at least 5 hours is to be provided for in every case.

(*b*) Generators for conditions of service requiring lighting periods of more than 5 hours to be of sufficient capacity to avoid recharging at night.

The following ratings will usually be found advisable:

1. For dwellings, and where machines are always used intermittently, the generator to have a rated capacity equal to the total number of burners installed.
2. For stores, opera houses, theaters, day-run factories, and similar service, the generator to have a rated capacity of from 30 to 50 per cent. in excess of the total number of burners installed.
3. For saloons and all-night or continued service, the generator to have a rated capacity of from 100 to 200 per cent. in excess of the total number of burners installed.

(*c*) A small generator should never be installed to supply a large number of lights, even though it seems probable that only a few lights will be used at a time. An overworked generator adds to the cost of producing acetylene gas.

5. *Carbide Charges.*—To be sufficient to furnish gas continuously for the maximum lighting period to all burners installed. In determining charges lump carbide to be estimated as capable of producing $4\frac{1}{2}$ cubic feet of gas to the pound, commercial $\frac{1}{4}$-inch carbide 4 cubic feet of gas to the pound, and burners to be considered as requiring at least 25 per cent. more than their rated consumption of gas.

6. *Burners.*—Burners consuming $\frac{1}{2}$ cubic foot of gas per hour are considered standard in rating generators. Those having a greater or less capacity will decrease or increase the number of burners allowable in proportion.

Burners usually consume from 25 to 100 per cent. more than their rated consumption of gas, depending largely on the working pressure. The so-called $\frac{1}{2}$-foot burner when operated at pressures of from 20 to 25 tenths inches water column (2 to $2\frac{1}{2}$ inches) is usually used with best economy.

7. *Piping.*—(*a*) Connections from generators to service pipes must be made with right- and left-thread nipples or long-thread nipples with locknuts. All forms of unions requiring gaskets are prohibited.

(*b*) Piping, as far as possible, to be arranged so that any moisture will drain back to the generator. If low points occur of necessity in any piping, they are to be drained through tees into drip cups permanently closed with screw-caps or plugs. No petcocks to be used.

(*c*) A valve and by-pass connection to be provided from the service pipe to the blow-off for removing the gas from the holder in case it should be necessary to do so.

(*d*) The schedule of pipe sizes for piping from generators to burners should conform to that commonly used for ordinary gas, but in no case are the feeders to be smaller than $\frac{3}{8}$ inch.

The following schedule is advocated:

$\frac{3}{8}$-inch pipe, 26 feet, three burners.
$\frac{1}{2}$-inch pipe, 30 feet, six burners.
$\frac{3}{4}$-inch pipe, 50 feet, twenty burners.
1 -inch pipe, 70 feet, thirty-five burners.
$1\frac{1}{4}$-inch pipe, 100 feet, sixty burners.
$1\frac{1}{2}$-inch pipe, 150 feet, one hundred burners.
2 -inch pipe, 200 feet, two hundred burners.
$2\frac{1}{2}$-inch pipe, 300 feet, three hundred burners.
3 -inch pipe, 450 feet, four hundred and fifty burners.
$3\frac{1}{2}$-inch pipe, 500 feet, six hundred burners.
4 -inch pipe, 600 feet, seven hundred and fifty burners.

(*e*) Machines of the carbide-feed type are not to be fitted with continuous drain connections leading to sewers, but must discharge into suitable open receptacles that may have such connections.

(*f*) Piping to be thoroughly tested both before and after the burners have been installed. It should not show loss, in excess of 2 inches of mercury within 12 hours when subjected to a pressure equal to that of 15 inches of mercury.

(*g*) Piping and connections to be installed by persons experienced in the installations of acetylene apparatus.

8. *Care and Attendance.*—In the care of generators designed for a lighting period of more than 5 hours, always clean and recharge the generating chambers at regular stated intervals, regardless of the number of burners actually used.

Where generators are not used throughout the entire year, always remove all water and gas and clean thoroughly at the end of the season during which they are in service.

It is usually necessary to take the bell portion out and invert it so as to allow all gas to escape. This should never be done in the presence of artificial light or fire of any kind.

Always observe a regular time, during daylight hours only, for attending to and charging the apparatus.

In charging the generating chambers of water-feed machines, clean all residuum carefully from the containers and remove it at once from the building. Separate from the mass any unslacked carbide remaining and return it to the containers, adding new carbide as required. Be careful never to fill the containers over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine are dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

Whenever recharging with carbide, always replenish the water supply; and in carbide machines be careful not to place in the generator less than 1 gallon of water for each pound of the carbide capacity, and not to bring the water above the point marked on the machine as the proper level.

Never deposit residuum or exhausted material from water-feed machines in sewer pipes or near inflammable material.

Always keep water tanks and water seals filled with clean water.

Never recharge carbide-feed generators with carbide without first cleaning out the generating chambers and completely refilling with clean water.

**Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.**

**Never use a lighted match, lamp, candle, lantern or any open light near the machine. Failure to observe the above cautions is as liable to endanger life as property.**

9. *Outside Generator Houses.*—(*a*) Outside generator houses should not be located within 5 feet of any opening into, nor shall they open toward any adjacent building, and must be kept under lock and key.

(*b*) The dimensions to be no greater than the apparatus requires to allow convenient room for recharging and inspection of parts.

(*c*) Generator houses to be thoroughly ventilated, and any artificial heating necessary to prevent freezing shall be done by steam or hot-water systems.

(*d*) Generator houses not to be used for the storage of calcium carbide except in accordance with the rules relating to that subject.

## CLASS B

### Stationary Non-Automatic Apparatus

10. *Foundations.*—(*a*) To be of brick, stone, or concrete.

(*b*) To be so arranged that the machine will be level and so that strain will not be brought upon the connections.

11. *Gas Houses.*—(*a*) To be constructed entirely of non-combustible material and must not be lighted by any system of illumination involving open flames.

(*b*) To be heated, where artificial heating is necessary to prevent freezing, by steam or hot-water systems, the heater to be located in a separate building, and no open flames to be permitted within generator enclosures.

(*c*) To be kept closed and locked except during daylight hours.

(*d*) To be provided with a permanent and effective system of ventilation which will be operative at all times, regardless of the periods of operation of the plant.

12. *Escape Pipes.*—Each generator to be provided with a vent pipe of ample size, substantially installed, without traps. It should be carried to a suitable point outside the building and terminate in an approved hood located at least 12 feet above ground and remote from windows.

The hood is to be constructed in such a manner that it cannot be obstructed by rain, snow, ice, insects, or birds.

13. *Care and Maintenance.*—All charging and cleaning of apparatus, generation of gas, and execution of repairs to be done during daylight hours only, and generators are not to be manipulated or in any way tampered with in the presence of artificial light.

This will require gas holders of a capacity sufficient to supply all lights installed for the maximum lighting period, without the necessity of generation of gas at night or by artificial light.

In the operating of generators of the carbide-feed type it is important that only a limited amount of carbide be fed into a given body of water. An allowance of at least 1 gallon of generating water per pound of carbide must be made in every case, and when this limit has been reached the generator should be drained and flushed, and clean water introduced. These precautions are necessary, to avoid overheating during generation and accumulation of hard deposits of residuum in the generating chamber.

## PART 2

## Rules for the Storage of Calcium Carbide

14. *Storage of Calcium Carbide.*—(*a*) Calcium carbide in quantities not to exceed 600 pounds may be stored, when obtained in approved metal packages not to exceed 100 pounds each, inside insured property, provided that the place of storage be dry, waterproof, and well ventilated, and also provided that all but one of the packages in any one building shall be sealed and the seals shall not be broken so long as there is carbide in excess of 1 pound in any other unsealed package in the building.

(*b*) Calcium carbide in quantities in excess of 600 pounds to be stored above ground in detached buildings, used exclusively for the storage of calcium carbide, in approved metal packages, and such buildings shall be constructed to be dry, waterproof, and well ventilated.

(*c*) Packages to be approved must be made of metal of sufficient strength to insure handling the package without rupture, and be provided with a screwed top or its equivalent.

They must be constructed so as to be water- and air-tight without the use of solder, and conspicuously marked "CALCIUM CARBIDE—DANGEROUS IF NOT KEPT DRY."

**PART 3**

## Rules for the Construction of Generators

### CLASS A

### Stationary Apparatus for Isolated Installations

15. *General Rules—Generators.*—(*a*) Must be made of iron or steel, and in a manner and of material to insure stability and durability.

(*b*) Must be automatically regulated and uniform in their action, producing gas only as immediate consumption demands, and so designed that gas is generated without producing sufficient heat to cause yellow discoloration of residuum, which will occur at about 500° F., or abnormal pressure at any stage of the process when using carbide of any degree of fineness.

The presence of excessive heat tends to change the chemical character of the gas and may even cause its ignition, while in machines of the carbide-feed type, finely divided carbide will produce excessive pressure unless provision is made to guard against it.

(*c*) Must be so arranged that during recharging back flow of gas from the gas holder will be automatically prevented, or so arranged that it will be impossible to charge the apparatus without first closing the supply pipe to the gas holder, and to the other generating chambers, if several are used.

This is intended to prevent the dangerous escape of gas.

(*d*) The water or carbide supply to the generating chamber must be so arranged that gas will be generated long enough in advance of the exhaustion of the supply already in the gas holder to allow the using of all lights without exhausting such supply.

This provides for the continuous working of the apparatus under all conditions of water feed and carbide charge, and it obviates the extinction of lights through intermittent action of the machine.

(*e*) No valves or petcocks opening into the room from the gas-holding part or parts, the draining of which will allow an escape of gas, are permitted, and condensation from all parts of the apparatus must be automatically removed without the use of valves or mechanical working parts.

Such valves and petcocks are not essential; their presence increases the possibility of leakage. The automatic removal of condensation from the apparatus is essential to the safe working of the machine.

**U** traps opening into the room from the gas-holding parts must not be used for removal of condensation. All sealed drip connections must be so arranged as to discharge gas to the blow-off when blown out, and the seals must be self-restoring upon relief of abnormal pressure.

(*f*) The apparatus must be capable of withstanding fire from outside causes.

Sheet-metal joints must be double seamed or riveted and thoroughly sweated with solder, or made in some substantial manner fully meeting the above requirements. Pipes must be attached to sheet metal with

substantial locknuts or riveted flanges, or by some other equally effective means.

This prohibits the use of wood or of joints relying entirely upon solder.

(*g*) Gauge glasses, the breakage of which would allow the escape of gas, must not be used.

(*h*) The use of mercury seals is prohibited.

Mercury has been found unreliable as a seal in acetylene apparatus.

(*i*) Combustible oils must not be used in connection with the apparatus.

(*j*) The construction must be such that liquid seals shall not become thickened by the deposit of lime or other foreign matter.

(*k*) The apparatus must be constructed so that accidental siphoning of water will be impossible.

(*l*) Flexible tubing, swing pipe joints, unions, springs, mechanical check valves, chains, pulleys, and lead or fusible piping must not be used on acetylene apparatus, except where failure of such parts will not vitally affect the working or safety of the machine or permit, either directly or indirectly, the escape of gas into the room.

Floats must not be used excepting in cases where failure will result only in rendering the machine inoperative.

(*m*) Every machine must be plainly marked with the maximum number of lights it is designed to supply, the amount of carbide necessary for a single charge, the manufacturer's name, and the name of the machine.

16. *Generating Chambers.*—(*a*) Must be constructed of galvanized iron or steel not less than No. 24 U. S. Standard gauge in thickness for capacities up to and including 20 gallons, not less than No. 22 U. S. Standard gauge for capacities between 20 and 75 gallons, and not less than No. 20 U. S. Standard gauge for capacities in excess of 75 gallons.

(*b*) Must each be connected with the gas holder in such a manner that they will, at all times, give connection either to the gas holder or to the blow-off pipe to the outer air.

This prevents dangerous pressure within or the escape of gas from the generating chamber.

(*c*) Must be so constructed that not more than 5 pounds of carbide can be acted upon at once, in machines which apply water in small quantities to the carbide.

This tends to reduce the danger of overheating and excessive after-generation by providing for division of the carbide charges in machines of this type.

(*d*) Must be provided with covers having secure fastenings to hold them properly in place, and those relying on a water seal must be submerged in at least 12 inches of water. Water-seal chambers for covers depending on a water seal must be $1\frac{1}{2}$ inches wide and 15 inches deep, excepting those depending upon the filling of the seal chambers for the generation of gas, where 9 inches will be sufficient.

(*e*) Must be so designed that the residuum will not clog or affect the working of the machine and can conveniently be handled and removed.

(*f*) Must be provided with suitable vent connections to the blow-off pipe so that residuum may be removed and the generating water replaced without causing siphoning or introducing air in any considerable quantity to the gas holder upon recharging.

(*g*) Feed mechanism for machines of the carbide-feed type must be so designed that the direct fall of carbide from the carbide holder into the water of the generator is prevented at all positions of the feed mechanisms; or, when actuated by the rise and fall of a gas bell, must be so arranged that the feed valve will not remain open after the landing of the bell, and so that the feed valve remains inoperative as long as the filling opening on the carbide hopper remains open. The feed of carbide should be so controlled that under no condition can more gas be generated than will be carried off by the safety relief, without an excessive rise of pressure. Feed mechanisms must always be far enough above the water level to prevent clogging from the accumulation of damp lime. For this purpose the distance should be not less than 10 inches.

17. *Carbide Chambers.*—(*a*) Must be constructed of galvanized iron or steel not less than No. 24 U. S. Standard gauge in thickness for capacities up to and including 50 pounds and not less than No. 22 U. S. Standard gauge for capacities in excess of 50 pounds.

(*b*) Must have sufficient carbide capacity to supply the full number of burners continuously and automatically during the maximum lighting period.

This rule removes the necessity of recharging or attending to the machine at improper hours. Burners almost invariably require more than their rated consumption of gas and carbide is not of staple purity, and there should therefore be an assurance of sufficient quantity to last as long as light is needed. Another important consideration is that in some establishments burners are called upon for a much longer period of lighting than in others, requiring a generator of greater gas-producing capacity. Machines having several generating chambers must automatically begin generation in each upon exhaustion of the preceding chamber.

(*c*) Must be arranged so that the carbide holders or charges may be easily and entirely removed in case of necessity.

18. *Gas Holders.*—(*a*) Must be constructed of galvanized iron or steel not less than No. 24 U. S. Standard gauge in thickness for capacities up to and including 20 gallons, not less than No. 22 U. S. Standard gauge for capacities between 20 and 75 gallons, and not less than No. 20 U. S. Standard gauge for capacities in excess of 75 gallons.

Gas bells, if used, may be two gauges lighter than holders.

Condensation chambers, if placed under holders, to be of same gauge as holders.

(*b*) Must be of sufficient capacity to contain all gas generated after all lights have been extinguished.

If the holder is too small and blows off frequently after the lights are extinguished,

there is a waste of gas. This may suggest improper working of the apparatus and encourage tampering.

(*c*) Must, when constructed on the gasometer principle, be so arranged that when the gas bell is filled to its maximum with gas at normal pressure its lip or lower edge will extend at least 9 inches below the inner water level.

(*d*) Must, when constructed on the gasometer principle, have the dimensions of the tank portion so related to those of the bell that a pressure of at least 11 inches will be necessary before gas can be forced from the holder.

(*e*) The bell portion of a gas holder constructed on the gasometer principle must be provided with a substantial guide to its upward movement, preferably in the center of the holder, carrying a stop acting to check the bell 1 inch above the normal blow-off point.

This tends to insure the proper action of the bell and decreases the liability of escaping gas.

(*f*) A space of at least $\frac{3}{4}$ inch must be allowed between the sides of the tank and the bell.

(*g*) All water seals must be so arranged that the water level may be readily seen and maintained.

19. *Water Supply.*—(*a*) The supply of water to the generator for generating purposes must not be taken from the water seal of any gas holder constructed on the gasometer principle, unless the feed mechanism is so arranged that the water seals provided for in Rules 18, (*c*), (*d*), and (*e*) may be retained under all conditions.

This provides for the proper level of water in the gas holder.

(*b*) The water capacity of the generating chamber of carbide-feed machines shall be such that not less than 1 gallon of water is provided for each pound of carbide.

(*c*) In cases where machines of the carbide-feed type are supplied with water from city water mains or house pipes, the pipe connection must discharge into the regularly provided filling trap on the generator and not through a separate continuous connection leading into the generating chamber.

This is to prevent the expulsion of explosive mixtures through the filling trap in refilling.

20. *Reliefs or Safety Blow-Offs.*—(*a*) Must in all cases be provided, and must afford free vent to the outer air for any over-production of gas, and also afford relief in case of abnormal pressure in the machine.

Both the above-mentioned vents may be connected with the same escape pipe.

(*b*) Must be of at least $\frac{3}{4}$-inch internal diameter and be provided with suitable means for connecting to the pipe leading outside of the building.

(*c*) Must be constructed without valves or other mechanical working parts.

(*d*) Apparatus requiring pressure regulators must be provided with an additional approved safety blow-off attachment located between the pressure regulator and the service pipes and discharging to the outer air.

This is intended to prevent the possibility of undue pressure in the service pipes due to failure of the pressure regulator.

21. *Pressures.*—(*a*) The working pressure at the generator must not vary more than ten-tenths (1) inch water column under all conditions of carbide charge and feed, and between the limits of no load and 50 per cent. overload.

(*b*) Apparatus not requiring pressure regulators must be so arranged that the gas pressure cannot exceed sixty-tenths (6) inches water column.

This requires the use of the pressure relief provided for in Rule No. 20 (*a*).

(*c*) Apparatus requiring pressure regulators must be so arranged that the gas pressure cannot exceed 3 pounds to the square inch.

The pressure limit of 3 pounds is taken, since that is the pressure corresponding to a water column about 6 feet high, which is about the limit in point of convenience for water-sealed reliefs.

22. *Air Mixture.*—Generators must be so arranged as to contain the minimum amount of air when first started or recharged, and no device or attachment facilitating or permitting mixture of air with the gas prior to consumption, except at the burners, shall be allowed.

Owing to the explosive properties of acetylene mixed with air, machines must be so designed that such mixtures are impossible.

23. *Purifiers, Scrubbers, and Filters.*—(*a*) Must be constructed of galvanized iron or steel not less than No. 24 U. S. Standard gauge in thickness.

(*b*) Where installed, purifiers must conform to the general rules for the construction of other acetylene apparatus and allow the free passage of gas.

(*c*) Purifiers must contain no carbide for drying purposes.

(*d*) Where located outside of gas holder must not have handholes which can be opened without first shutting off the gas supply.

24. *Pressure Regulators.*—(*a*) Must conform to the rules for the construction of other acetylene apparatus so far as they apply and must not be subject to sticking or clogging.

(*b*) Must be capable of maintaining a uniform pressure, not varying more than $\frac{4}{10}$-inch water column, at any load within their rating.

(*c*) Must be installed between valves in such a manner as to facilitate inspection and repairs.

## CLASS B

### Stationary Apparatus for Central-Station Service

Generators of over 300 lights capacity for central-station service are not required to be automatic in operation. Generators of less than

300 lights capacity must be automatic in operation and must comply in every respect with the requirements of Part 3, Class A.

25. *General Rules—Generators.*—(*a*) Must be substantially constructed of iron or steel and be protected against depreciation by an effective and durable preventive of corrosion.

Galvanizing is strongly recommended as a protection against oxidation, and it may to advantage be reinforced by a thorough coating of asphaltum or similar material.

(*b*) Must contain no copper or alloy of copper in contact with acetylene, excepting in valves.

(*c*) Must be so arranged that generation will take place without overheating; temperatures in excess of 500° F. to be considered excessive.

(*d*) Must be provided with means for automatic removal of condensation from gas passages.

(*e*) Must be provided with suitable protection against freezing of any water contained in the apparatus.

No salt or other corrosive chemical is permissible as a protection against freezing.

(*f*) Must in general comply with the requirements governing the construction of apparatus for isolated installations so far as they are applicable.

(*g*) Must be so arranged as to insure correct procedure in recharging and cleaning.

(*h*) Generators of the carbide-feed type must be provided with some form of approved measuring device to enable the attendant to determine when the maximum allowable quantity of carbide has been fed into the generating chamber.

In the operation of generators of this type an allowance of at least 1 gallon of clean generating water per pound of carbide should be made, and the generator should be cleaned after slaking of every full charge. Where lump carbide is used, the lumps may become embedded in the residuum, if the latter is allowed to accumulate at the bottom of the generating chamber, causing overheating from slow and restricted generation, and rendering the mass more liable to form a hard deposit and bring severe stresses upon the walls of the generator by slow expansion.

26. *Generating Chambers.*—(*a*) Must each be connected with the gas holder in such a manner that they will, at all times, give open connection either to the gas holder or to the blow-off pipe into the outer air.

(*b*) Must be so arranged as to guard against appreciable escape of gas to the room at any time during the introduction of the charges.

(*c*) Must be so designed that the residuum will not clog or affect the operation of the machine and can conveniently be handled and removed.

(*d*) Must be so arranged that during the process of cleaning and recharging back flow of gas from the gas holder or other generating chambers will be automatically prevented.

27. *Gas Holders.*—(*a*) Must be of sufficient capacity to contain at least 4 cubic feet of gas per $\frac{1}{2}$-foot burner of the rating.

This is to provide for the requisite lighting period without the necessity of making gas at night, allowance being made for the enlargement of burners caused by the use of cleaners.

(*b*) Must be provided with suitable guides to direct the movement of the bell throughout its entire travel.

28. *Pressure Reliefs*.—Must in all cases be provided, and must be so arranged as to prevent pressure in excess of 100 tenths (10) inches water column in the mains.

29. *Pressures*.—Gas holders must be adjusted to maintain a pressure of approximately 25 tenths (2.5) inches water column in the mains.

## CLASS C

### High-Pressure Acetylene Apparatus for Vehicle and Vessel Lighting

Note.—A complete set of plans and specifications of proposed installations of generating and compressing plants should be submitted to the underwriters having jurisdiction before beginning construction.

Installation of acetylene generating apparatus in or upon cars or other railway rolling stock or upon vessels is not permitted; the service tanks are completely filled with acetone or its equivalent absorbed in an approved porous material, which must be of such nature as to absolutely prevent any hazardous dissociation of the gas from shock, heat, electric spark, or other method which may be employed in making tests, and when such storage systems are constructed, installed, and operated in accordance with the following rules:

The use of liquid acetylene, or gas generated therefrom, or any system of generation of acetylene under a pressure in excess of 15 pounds per square inch is absolutely prohibited.

1. *Service Tanks*.—(*a*) Tanks must be made of steel and constructed with a factor of safety of not less than six. The steel used must be of such a quality that when ruptured by interior pressure the metal will tear rather than break in pieces.

Note.—Where tanks must be frequently handled or are subjected to severe service conditions, they should be periodically tested by water-jacket or other suitable method, to a uniform pressure not less than twice the normal charging pressure. Tanks must be condemned where local weakness is shown or where the permanent distortion, measured volumetrically, exceeds 5 per cent. of the total distortion under pressure. Date of test should be permanently marked on tank.

(*b*) Tanks must be thoroughly protected by an effective and durable preventive of corrosion.

(*c*) Tanks must be provided with some suitable means of automatically relieving excessive pressure, due to fire or other causes. Such reliefs must not operate at a pressure lower than 25 per cent. in excess of test pressures to which the tank may be subjected.

Note.—In transportation, or storage, tanks should be kept in a cool place, and must not be placed near radiators, stoves, or other sources of heat. Storage of tanks to be in a well-ventilated compartment which is to be locked.

(*d*) Tanks in service must be located outside of the vehicle or on the decks of vessels. If otherwise located, they should be placed in compartments used for no other purpose, which shall be thoroughly ventilated to the outer air.

2. *Pressures.*—Tanks must not be charged to a service pressure in excess of 250 pounds per square inch at a temperature of 70° F.

3. *Valves.*—(*a*) Each tank must be provided with an outlet valve which is arranged to close against the pressure.

(*b*) A readily accessible service valve of approved design is to be installed in the pipe line. This valve to be operated only by a key.

NOTE.—This service valve should not be used on tanks of small capacity such as are installed on automobiles.

4. *Pressure Regulator.*—An approved pressure regulator to be installed, which shall automatically maintain the pressure at the burners within such limits that, under all working conditions, the variation in the illumination will be inappreciable. When installed within the car to be provided with a suitable vent to the outer air.

NOTE.—On automobile installations, where the gas consumption is not over 3 cubic feet per hour, the automatic regulator may be dispensed with where the gas tank is provided with a combination shut-off and regulating valve of approved form.

5. *Piping.*—(*a*) For railway-car and vessel installations all piping between tank and regulator to be extra-strong wrought-iron or steel pipe. Piping of lighting system between regulator and burners to be standard full weight wrought-iron or steel pipe.

(*b*) Piping to be carefully installed and thoroughly tested. It must not show leakage in excess of 2 inches of mercury within 12 hours, when subjected to a pressure equal to that of 15 inches of mercury.

(*c*) Piping for automobile installations to be seamless brass tubing of small size, which must be protected against wear due to jarring and vibration. Copper must not be used for tubing or other parts in contact with acetylene.

NOTE.—Lamp and tank connections for automobile installations should be made by means of rubber tubing which in case of excessive pressure will blow off and prevent accumulation of high pressure in the pipe line.

6. *Generating, Compressing, and Charging Plant.*—Generating, compressing, and charging to be preferably carried on in separate rooms or buildings and such building or buildings to be detached not less than 50 feet.

(*a*) Station to comply in general construction with Rule 11, Class B.

(*b*) Acetylene gas from the generators to be purified, dried, and filtered before being compressed. Such apparatus as may be used in these processes to comply with the general rules for generator construction.

(*c*) All compressors for use with acetylene must be so made that, when operated continuously at their rated capacity, the gas at no stage of compression shall show a temperature of more than 100° F. above the temperature of the surrounding air.

(*d*) All piping used to be extra-strong wrought iron or steel and to be as small in diameter as is commensurate with the proper flow of gas.

NOTE.—All pipe lines for conveying acetylene should be divided into sections not over 100 feet long by efficient back-flash preventers in order to localize any explosion in the system.

7. *Gas Storage and Piping.*—(*a*) All gas holders should be so located as not to expose other property.

(*b*) Charging of service tanks by pipe lines or portable storage tanks in railway yards is not desirable. Where permitted, rigid precautions should be taken to prevent leakage of acetylene and all piping should be extra-strong and well protected against injury or corrosion.

NOTE.—No piping carrying acetylene should be permitted in or under railway stations, sheds, platforms, or buildings of any kind where escaping gas might accumulate, and charging should only be done in the open air and at times when artificial light is not needed. All outlet valves to be thoroughly protected against tampering or damage. Flexible metallic tubing of approved construction should be used to connect the gas outlets to the service tank and no valves should be provided on other than the rigid piping.

8. *Care and Attendance.*—Generators, charging apparatus, and other details to be under expert supervision at all times.

## CLASS D

### PORTABLE TABLE LAMPS

30. *General Rules—Lamps.*—(*a*) Must be substantially made of metal, and the construction must embody no copper, either pure or alloyed, in contact with acetylene.

(*b*) Must in all parts subject to corrosion be thoroughly protected by an effective and durable preventive of rust.

(*c*) Must be designed with a view to stability, the assembly being such that when completely charged and ready for operation, inclination at an angle of 30 degrees with the vertical will not result in upsetting.

(*d*) Must be fitted with not more than one single or multiple burner and the total rated gas consumption must not be more than $\frac{3}{4}$ cubic foot per hour.

(*e*) Must be automatically regulated and uniform in their action, producing gas only as immediate consumption demands, and be so designed that gas is generated without producing sufficient heat to cause yellow discoloration of the residuum, which will occur at about 500° F., or abnormal pressure at any stage of the process when using carbide of any degree of fineness.

(*f*) Must have no mechanical or spring relief valves, and must be so designed as to prevent automatically the accumulation of excessive pressure when placed in any position or overturned.

(*g*) No valves or petcocks opening into the room from gas-holding parts, the draining of which would allow an escape of gas, are permissible, and condensation from all parts of the apparatus must be automatically disposed of without the use of valves or mechanical working parts.

(*h*) Gauge glasses, the breakage of which would allow escape of gas, must not be used.

(*i*) The use of mercury seals is prohibited.

Mercury has been found unreliable as a seal in acetylene apparatus.

(*j*) Combustible oils must not be used in connection with the apparatus.

(*k*) Water seals, the breakage of which would allow escape of gas into the room, are prohibited.

(*l*) Every lamp must be provided with a permanent marking, stating plainly the amount of carbide necessary for a single full charge, the manufacturer's name, and the name of the lamp.

31. *Generating Chambers.*—(*a*) Must be so designed that generation will take place under conditions similar to those which obtain in the best generator practice.

(*b*) Must afford ample room for the residuum without containing unnecessary air spaces.

(*c*) Must be so designed that the residuum will not clog or affect the working of the device and be so arranged that the residuum can conveniently be handled and removed.

32. *Carbide Receptacles.*—(*a*) Must have sufficient carbide capacity to supply, continuously, the burner for which the lamp is rated during a lighting period of not less than 6 hours.

In determining charges the yield of gas from the various grades of carbide must be estimated as follows:

| | |
|---|---|
| From the 3½ in. × 2 in. grade | 4½ cubic feet per lb. |
| From the 2 in. × ¾ in. grade | 4½ cubic feet per lb. |
| From the ¾ in. × ¼ in. grade | 4¼ cubic feet per lb. |
| From the ¼ in. × 1/12 in. grade | 4 cubic feet per lb. |
| From the "Electrolite" | 4 cubic feet per lb. |

These figures are specified, in order that a reasonable allowance may be insured for depreciation after the initial opening of the package.

The gas consumption of burners must be estimated at 50 per cent. in excess of the rating.

(*b*) Must be arranged so that the carbide holders or charges may be easily and entirely removed in case of necessity.

(*c*) May in no case have capacity for more than 2 pounds of carbide.

33. *Water Supply.*—Must be similar in quantity to the allowance made in the best generator practice.

34. *Pressures.*—(*a*) The working pressure at the burner must not vary more than ten-tenths (1) inch water column under all conditions of carbide charge and feed.

(*b*) Lamps requiring pressure regulators or reducers must be so constructed as to withstand without injury a pressure equivalent to four times the maximum pressure obtainable in normal operation.

35. *Pressure Regulators.*—(*a*) Must conform to the rules for the construction of other acetylene apparatus so far as they apply, and must not be subject to sticking or clogging.

(*b*) Must be capable of maintaining a uniform pressure, not varying more than four-tenths inch water column, at any load within their rating.

36. *Purifiers.*—Where installed, purifiers must conform to the general rules for the construction of other acetylene apparatus and allow the free passage of gas.

37. *Means of Control.*—(*a*) Must be such as to obviate accumulation of pressure within the lamp or appreciable discharge of gas after extinction of the light.

(*b*) Must be so arranged as to necessitate tight closure of the carbide filing opening before the feed can be put into operation.

**68. Permitted Machines.**—A list of such acetylene generators as have been examined, tested, and found to be safeguarded as far as possible, is issued from time to time. Copies of these lists may be obtained by application to the National Board of Fire Underwriters.

## GASOLINE GAS

### GENERAL DISCUSSION

**69.** Gasoline gas, or *carbureted air*, also called *air gas*, is a mixture of gasoline vapor with air. The pure vapor is so rich in carbon that, in order to burn it successfully for lighting purposes, it must have a high pressure; and special burners must be employed, as for acetylene. In order to burn it in the same burners used for illuminating gas and at the same pressure, it must be diluted with air until the proportion of carbon equals that in ordinary coal gas.

The air furnishes a part of the oxygen required for combustion, but it also introduces a large proportion of nitrogen, which is inert and useless material, being incombustible; the nitrogen reduces the temperature of the flame and thus diminishes its brilliancy.

Gasoline is produced by distilling crude petroleum. Its specific gravity averages about .75 that of water. It is really a mixture of a large number of hydrocarbon compounds that differ slightly in their chemical proportions. All of them, however, will change from the liquid to the gaseous form,

under ordinary atmospheric pressure, at a temperature ranging from 70° to 100°. If a tank containing liquid gasoline is opened to the air, the liquid will all pass away in the form of gas. The rapidity of the evaporation will depend on the temperature, being very slow at 40°, quite rapid at 70°, and furious at 212°; and, if the liquid catches fire in any way, it will pass into gas with explosive violence. The burning liquid expands enormously and is very difficult to extinguish. Gasoline must be regarded as gas in a liquid form and it should be clearly understood that it will resume the gaseous form whenever the opportunity is afforded. The effect of leaving a can of gasoline uncorked is exactly the same as that of leaving a gas-cock open; in both cases the gas will diffuse through the atmosphere and form explosive mixtures.

Gasoline is generally regarded as a dangerous material to use or handle, but the danger arises from the recklessness or neglect of the persons using it. If the same care is taken to keep it shut up as is taken to keep coal gas confined, it is no more dangerous than the latter. A tank of gasoline should be treated as a reservoir of gas.

**70.** There are different grades of gasoline in the market, which differ in their specific gravities. A gasoline called **crude naphtha** has a specific gravity of .6, and is used for making illuminating gas. For cooking stoves, for plumbers' torches, and for firepots, gasoline having a specific gravity from .7 to .74, is adapted. For use in gas engines, as in automobiles, a gasoline having a specific gravity of .74 is used. For gas machines the specific gravity should be .86 for the summer and .88 for the winter. The highest grade is sometimes called **winter gasoline**; its specific gravity is about .9. This grade will evaporate at ordinary temperatures and leave nothing behind. The poorer grades contain more or less oil that will not evaporate without the aid of heat; this oil collects in the gas-generating apparatus and must be removed from time to time. It is usually thrown away, but it is very similar to low-grade kerosene, and will burn in the same manner in gasoline stoves.

It has become the custom in the trade to designate the specific gravity of gasoline in per cent., water being considered as 100. Thus, when an 86-per-cent. gasoline is mentioned, a gasoline having a specific gravity of .86 is meant.

**71.** The quantity of gasoline that is required to produce 1,000 cubic feet of gas, and that will give a light of from 14 to 16 candles, when burning at the rate of 5 cubic feet per hour, is about 4½ gallons of the best grade; more is required if the gasoline is of a lower grade.

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## GASOLINE-GAS MACHINES

**72. Generator.**—The apparatus used for making illuminating gas from gasoline consists of three parts: a generator for holding the gasoline, an air pump for forcing air through the generator, and a mixing device for mingling the air and vapor in proper proportions.

The vapor is made by simple evaporation, without the aid of heat. The liquid is spread out in large shallow pans, and the air is compelled to pass successively over its surface in all the pans. The construction of the evaporator, or generator, is shown in Fig. 13. Three pans *a*, *b*, and *c*, and sometimes more, are employed, and all are enclosed in a gas-tight casing having an opening *i* in the side for the inlet of air and another opening at *d* for the outlet of gas. Some parts of the gasoline evaporate slowly, and it is necessary to have large evaporating surfaces, so that a proper amount of vapor will be given off when the lighter parts of the liquid have been evaporated and only the heavier parts remain. In order to increase the evaporating surface, the pans are partly filled with cotton or similar porous materials that absorb the gasoline, and the air is forced to pass partly through the mass of absorbent material. A common practice is to arrange some capillary material woven into a coarse fabric in the zigzag manner shown, so that the air will be compelled to flow through the meshes of this netting and thereby absorb the gasoline that is drawn up by capillary attraction.

The generator is charged by pouring the gasoline down through the pipe *e* into the upper pan *c*. The pipe *f*, through which *e* is slipped, forms an outlet tube for air while the generator is being filled with gasoline. When this pan becomes full, the liquid overflows into the next pan below, and thus they are all filled successively. Should the bottom pan become too full, the excess may be pumped out by attaching a pump to the top of the tube *g*.

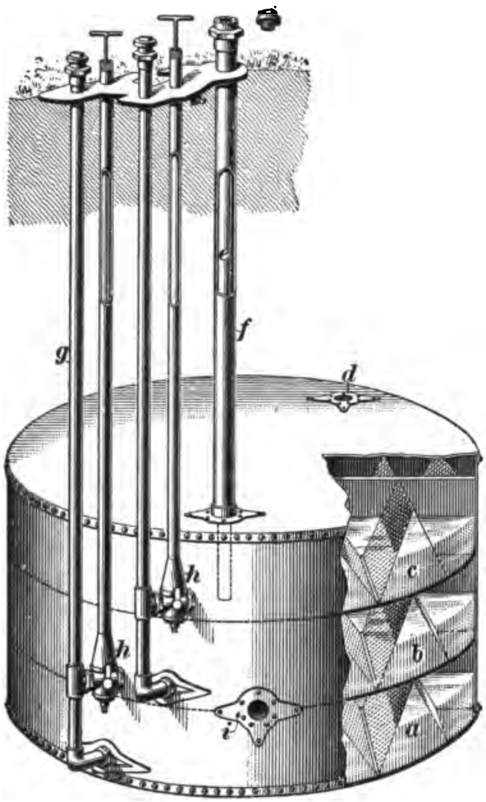

FIG. 13

When the lighter parts of the gasoline have been evaporated from any one pan, the remainder is usually dropped into the next pan below by opening one of the cocks *h*. The waste liquid collects in the bottom pan and may be removed from time to time by pumping through the tube *g*.

The generator is buried in the earth outside of all buildings, for fear of possible explosions. It must be buried deep enough to avoid all risk of freezing, because at temperatures below 32° the liquid evaporates too slowly to answer the purpose. The handles of the valves, and all the pipes needed for testing and filling, are extended upwards to the surface of the ground and are protected from the weather by a suitable water-tight box and

cover. It was formerly customary to place the generator in an underground vault. The advantage of this arrangement was that the generator was fully accessible; but the construction of the vault increased the total cost of the apparatus so much that the plan has been nearly abandoned. The buried generators need to be strongly built to stand the pressure of the earth around and above them.

**73. Air Pump.**—The air pump may be of any suitable design; the kind commonly used is shown in Fig. 14. It closely resembles the wet-gas meter in construction and principle, except that the drum is rotated by power so as to act as a force pump instead of as a meter. The drum is turned by means of a heavy weight *k* and a cord that is wound around the pulley *l*. It turns very slowly, even when working at full speed. The weight is required to be wound up at intervals of from 3 to 4 days or more, according to the demand for gas.

The pump should take air from some place that is never at a freezing temperature, because cold air checks evaporation in the generator.

The body of the machine is filled with water up to a certain mark, which is usually visible through a mica bull's eye. The water evaporates slowly and must be replenished from time to time. The air is driven through the pipe *m* to the generator *a*, and returns mixed with vapor through the pipe *p*.

When the gasoline is cold, or is nearly spent, the proportions of the air and vapor must be changed, in order to maintain the illuminating power of the gas at the standard desired. Otherwise, the gas will be too rich, that is, it will contain too much carbon; consequently, it will smoke in summer time and will burn pale and blue in very cold weather. This difficulty is sometimes met by using adjustable burners, but the drawback to that arrangement is that all the burners must be adjusted at intervals to suit the varying quality of the gas.

If a mixing device is used, then all the necessary adjustments can be made at one point and ordinary batswing burners may be used without any trouble.

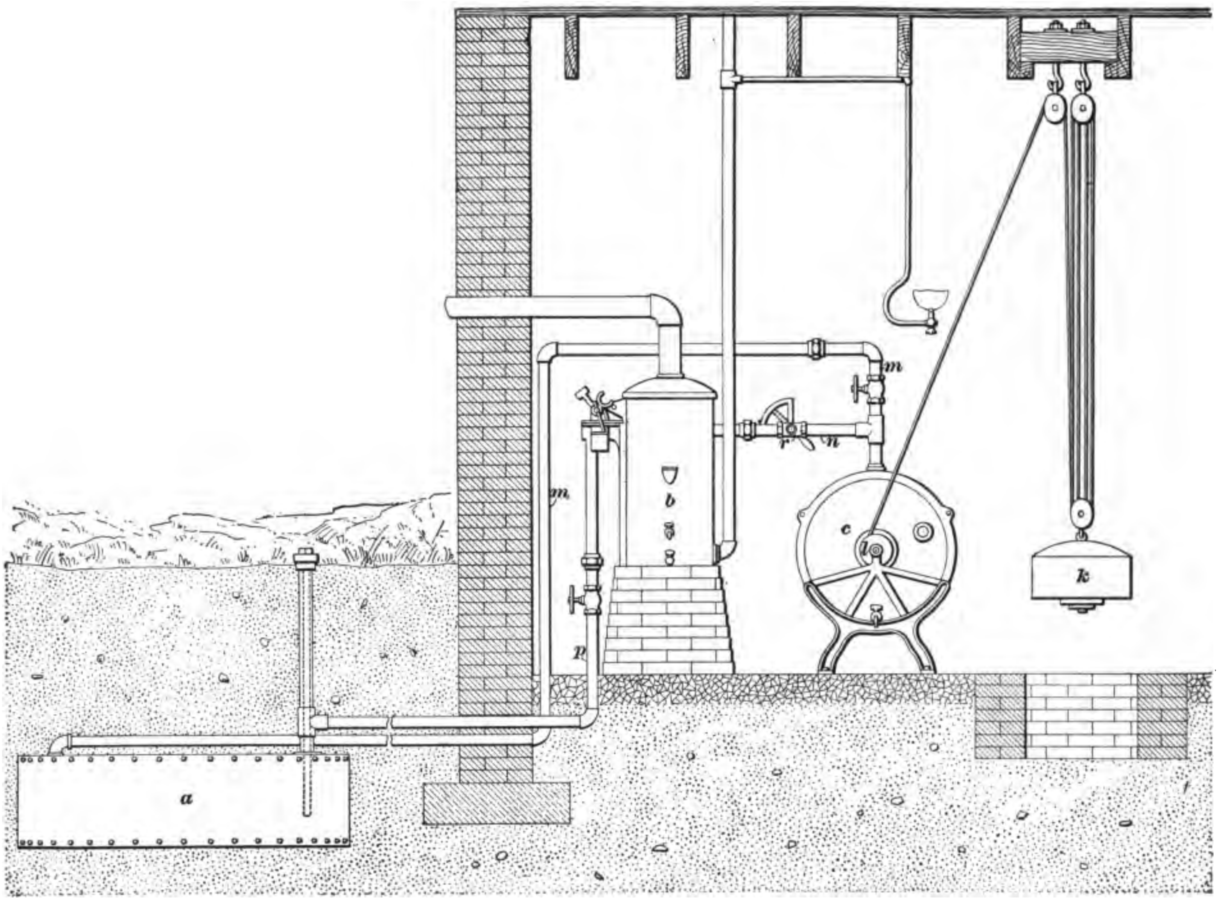


FIG. 14

**74. Mixing Device.**—The mixing device consists of a by-pass pipe *n*, Fig. 14, connecting the air pipe *m* with the gas pipe *p*. It is provided with a cock *r*, having an index and pointer, by which it can be adjusted to any desired amount of opening. The mixing device is not automatic, but must be adjusted by hand.

When the apparatus runs very slowly, or stands still for a while, the gasoline vapor, with a direct connection, will diffuse throughout the pipes *m* and *n* and back into the pump. The mixer is then useless. This trouble may be prevented by means of the regulator shown in Fig. 15, which is an enlarged sectional drawing of the regulator *b* in Fig. 14.

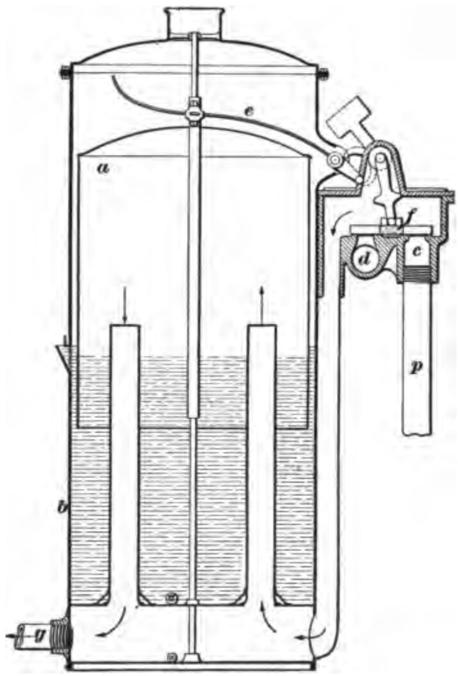

FIG. 15

The gas coming from the generator is introduced at *c*, Fig. 15, and the air from the by-pass pipe is brought in at *d*. Both openings are controlled by a slide valve *f*. The gas is discharged into the distributing pipe at *g*. When gas is passing through the machine, the drum *a* alternately fills and empties, rising and falling in the water tank *b*.

When it rises, it fills with gas from *c* and fresh air from *d*, according to the adjustment of the by-pass cock. When it reaches the top of its stroke, it moves the lever *e* and closes the valve *f*. The mixture within the drum is thus cut off from all communication with the generator or the pump:

consequently, its proportions cannot be changed by standing for any length of time. When the drum sinks to the bottom of its stroke and is nearly empty, it moves the lever *e* in the opposite direction and opens the valve *f*, thus admitting a new charge. The water in the tank gradually evaporates when the machine is in use and must be replenished occasionally.

**75. Effect of Poor Gasoline.**—When a poor grade of gasoline is used in making the gas, the generator gradually becomes clogged with an oil that will not evaporate freely and that for the purpose of gas making is spent and useless. This oil is generally pumped out and thrown away. It should not be thrown into a drain or a sewer, because it will fill them with explosive gas. It should not be thrown into a stream of water, because of the danger from fire to everything adjoining the water, and because of the stench to which it will give rise.

**76. Precautions Against Frost.**—All the pipes in the gas apparatus, and the house pipes as well, must be kept out of reach of frost, and if they are exposed they must be well protected. The pipes must be graded, drained, and provided with drip cups in the same manner as with coal gas, etc. A low pressure is generally used throughout the system of distributing pipes; and, therefore, the pipes are usually made a little larger than for coal gas.

**77. Gas Machines for Manufacturing Purposes.**—The apparatus used for making gas from gasoline for manufacturing purposes is very simple. The air is supplied by a common steam pump at a pressure of 3 or 4 pounds per square inch. The gasoline is contained in strong vertical cylinders, which are loosely filled with cotton or other absorbent fibers, and the air is forced through the mass. The temperature of the air is raised a few degrees by the process of compression and the warmth aids the evaporation of the gasoline. The quality of the gas is maintained at any desired standard, by pumping fresh gasoline into the generator whenever it is required. In some forms of apparatus, the evaporation of the gasoline is aided by the application of a moderate steam heat.

When gas is formed by the aid of heat, care must be taken to prevent it from cooling to any considerable extent, because a part of it will then condense into liquid form again.

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### GASOLINE-VAPOR GAS-LIGHTING MACHINES

**78. Construction, Installation, and Use.**—Following are the Rules and Requirements of the National Board of Fire Underwriters for the construction, installation, and use of gasoline-vapor gas-lighting machines, lamps, and systems. These rules were adopted on the recommendation of the Committee of Consulting Engineers appointed by the Board:

#### CLASS A

#### Machines Having Outside Carbureters

These machines, which do not introduce liquid gasoline into the building, are regarded from an insurance viewpoint as constituting the least dangerous type of gasoline gas machine. When used, the following rules should be rigidly observed:

1. *Carbureters.*—(*a*) To be located outside the building, underground, at least 30 feet removed from all buildings, and the top thereof must be below the level of the lowest pipe in the building used in connection with the apparatus.

(*b*) To be located well below the frost line in all cases and be set level on a firm foundation.

(*c*) Must be constructed in a substantial and rigid manner and braced sufficiently to safely support the weight of the earth under which it is buried.

(*d*) Must be painted on the outside with a heavy coat of tar or varnish impervious to the corrosive action of the moisture and mineral salts contained in the earth.

(*e*) Must be constructed of sheet copper or of galvanized sheet steel, not less than No. 19 U. S. gauge in thickness for diameters up to and including 6 feet, and not less than No. 18 U. S. gauge for diameters over 6 feet.

(*f*) Joints in the outer shell must be double seamed or riveted, and all joints, rivets, and cut edges of sheet steel must be thoroughly sweated with solder.

(*g*) Must have sufficient evaporating surface exposed to the air to insure the production of a thoroughly saturated non-explosive vapor, and be of sufficient size to supply the rated capacity of the machine indefinitely without excessive refrigerating effect.

(*h*) Must be provided with fill and vent pipes so arranged that the fill pipe cannot be opened without opening the vent pipe; these to terminate in a metal box, or casting, provided with a lock. Pipes to be provided with screens.

2. *Blower.*—(*a*) To be located on a solid, level foundation.

(*b*) If constructed with a water seal, to be located in a room where the temperature does not fall to the freezing point.

(*c*) Must be entirely automatic in action and regulation under all conditions of service.

(*d*) Weight-driven blowers must be arranged so that the weight may be wound up at any time without affecting the pressure or the lights.

3. *Mixer.*—

NOTE.—Mixers which are entirely automatic, self-governing, and which produce a uniform quality of gas under all conditions, are preferred.

(*a*) Must have no open connection to the outside air except through the blower.

(*b*) Mixers containing water-sealed chambers must be provided with a relief or safety blow-off, constructed without valves or other mechanical working parts, and arranged to discharge through an escape or relief pipe of at least $\frac{3}{4}$ inch internal diameter. This pipe must be installed without traps and carried to a suitable point outside the building and terminate in an approved hood located out of reach and remote from windows.

(*c*) If constructed of sheet metal instead of cast iron, all joints must be double seamed or riveted. If sheet steel is used, it must be galvanized and all cut edges and rivets thoroughly sweated with solder.

4. *Pressure Regulator.*—(*a*) Must not depend upon springs for proper operation.

(*b*) Must have no materials in contact with the gas which will be injured by gasoline vapor.

(*c*) Must be installed between valves in such a manner as to facilitate inspection and repairs.

5. *Outside Piping.*—(*a*) None but tested pipe to be used.

(*b*) Connections to outside tank or carbureter must not be located near, nor placed in the same trench with, other piping.

(*c*) The piping to the building to have an incline toward the carbureter of not less than 1 inch in 10 feet.

(*d*) All piping to be laid below the frost line on solid earth. Propping the pipes on wooden blocks or sticks in the trench should be avoided.

(*e*) Openings for pipes through outside walls to be securely cemented and made water-tight.

(*f*) Fill, vent, and transfer pipes extending to the surface of the ground to be boxed or provided with enclosing sleeves to prevent the freezing of earth about them and consequent loosening or breaking of connections.

(*g*) In connecting pipes to tank or carbureter a swing joint can be made with fittings which will compensate for settling.

6. *Inside Piping.*—(*a*) The air pipe from the pump to be carried at least 24 inches higher than the top of the filler pipes of the carbureter.

(*b*) Pipe connections by right and left couplings or by long screws with couplings and locknuts faced, are advised, where practical, in place of unions. If unions are used they must be of approved type having at least one face of the joint made of brass and having a ground conical joint, obviating the use of packing or gaskets.

(*c*) Under no circumstances should there be sags or traps. The piping system to have an unbroken and untrapped continuous incline from the most distant fixture connection back and into the main riser, and thence out to the carbureter.

(*d*) All side brackets should be supplied from the horizontal pipe in the floor below and not from the horizontal pipe in the ceiling above, and all ceiling fixtures should connect to the side or top of the supply pipe.

(*e*) Main risers should be located as near the machine as practicable and should be run up through an inside partition, if possible, rather than upon an outside wall where cold air may strike them.

NOTE.—When risers or branch pipes must be run up on the outside walls or where exposed to the cold, they should be wrapped with suitable insulating material, or carefully boxed, to properly protect them.

(*f*) The following schedule of pipe sizes for gasoline vapor gas is advocated:

| | |
|---|---|
| Size of main riser for 20 to 30 lights | 1 inch |
| Size of main riser for 40 to 50 lights | 1¼ inches |
| Size of main riser for 75 to 100 lights | 1½ inches |
| Size of main riser for 150 to 200 lights | 2 inches |
| Size of main riser for 300 lights | 2½ inches |
| Size of main riser for 500 lights | 3 inches |
| Size of main riser for 750 lights | 4 inches |
| Size of main riser for 1000 lights | 5 inches |

No riser in any building should be less than 1 inch inside diameter.

(*g*) For branches, the accompanying table gives the proportionate sizes and lengths of branches:

| Size of Pipe | Greatest Length Allowed | Greatest Number Lights |
|---|---|---|
| ⅜ inch | 15 feet | 3 |
| ½ inch | 20 feet | 6 |
| ¾ inch | 50 feet | 12 |
| 1 inch | 75 feet | 25 |
| 1¼ inches | 90 feet | 75 |
| 1½ inches | 125 feet | 100 |
| 2 inches | 150 feet | 200 |

No pipe used in any portion of the building, even though it is only to supply one light, should be less than ⅜ inch inside diameter.

(*h*) Piping to the burners shall be thoroughly tested before the gas machine is attached and must not show loss within 15 minutes when subjected to a pressure equivalent to 10 inches of mercury.

(*i*) Piping and connections must be installed by experienced persons.

(*j*) Brass wire gauze having a mesh of at least 20 per inch, or its equivalent, must be provided between the service pipe and the machine,

the same to be secured in a substantial and rigid manner without the use of solder.

NOTE.—Lead, gas-fitters' cement, or other substances affected by gasoline and its vapor, must not be used in making joints in piping.

7. *Care and Attendance.*—(*a*) Filling of carbureters must always be done by daylight; no blaze or artificial lights should be allowed in the vicinity.

(*b*) Empty gasoline barrels must be put in a safe place in the open air with bung hole down.

(*c*) A regular time should be set for attending to the apparatus and keeping the same in proper working condition.

(*d*) Water seals of blowers or mixers must always be kept filled to the indicated level with clean water.

(*e*) Never test the apparatus or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.

## CLASS B

### MACHINES HAVING INSIDE CARBURETERS

These machines are regarded from an insurance viewpoint as more dangerous than those having outside carbureters, owing to the fact that they introduce gasoline in liquid form and manufacture gas inside the building. Where permitted, the following rules and precautions should be rigidly observed:

8. *Supply Tank.*—(*a*) Must be located outside the building, underground where possible, at least 30 feet removed from all buildings and below the level of the lowest pipe in the building used in connection with the apparatus.

(*b*) If impracticable to bury the supply tank, the same may be installed in a non-combustible building or vault properly ventilated, preferably from the bottom, always remembering that it must be below the level of the lowest pipe in the building used in connection with the apparatus.

(*c*) Must be constructed of iron or steel plate, not less than No. 18 U. S. gauge in thickness, with joints riveted together or double seamed. Tanks should be galvanized or painted on the outside with rust-proof paint.

(*d*) Must be approved, with fill and vent pipes so arranged that the fill pipe cannot be opened without opening the vent pipe; these to terminate in a metal box, or casting, provided with a lock. Pipes to be provided with screens.

9. *Carbureter.*—(*a*) Must not contain at any time more than 1 quart of gasoline.

(*b*) Must be substantially constructed in an approved manner, of sheet metal, preferably brass or copper, of at least No. 20 B. & S. gauge in thickness or else made in a casting.

(*c*) Must be provided with an overflow connection draining back to the outside supply tank.

(*d*) Must have no valves opening into the room.

(*e*) No artificial heat other than hot water or steam to be used to produce rapid evaporation, and in all cases to have heating and evaporating chambers entirely separate.

(*f*) The apparatus must be capable of withstanding fire from outside causes without falling apart or allowing the escape of gas.

This prohibits the use of wood or of joints relying entirely upon solder.

(*g*) Gauge glasses, the breakage of which would allow the escape of gas, must not be used.

10. *Gasoline Feed-Pump.*—(*a*) If of the simple plunger type, must have check-valves as close to the pump as convenient.

(*b*) Plunger must be provided with a substantial stuffingbox to prevent leakage. Use cupped gland within same to compress the packing against the plunger. Packing affected by gasoline must not be used.

11. *Piping and Fittings.*—Follow the same requirements as given under Class A, except in the following particulars:

(*a*) The pipes connecting the carbureters to the supply tank to have an incline toward the tank of not less than 1 inch in 5 feet.

(*b*) Tank and drain piping must be of galvanized iron not smaller than $\frac{3}{8}$-inch size. Drain pipe to be at least one size larger than supply pipe.

(*c*) Pipe connections by right and left couplings or by long screws with couplings and locknuts faced, are advised, where practical, in place of unions. If unions are used they must be of approved type having at least one face of the joint made of brass and having a ground conical joint, obviating the use of packing or gaskets.

(*d*) A filter must be provided in the gasoline supply pipe located near the pump and accessible for purposes of cleaning.

NOTE.—A substantial fitting containing fine brass gauze is recommended for use as a filter.

(*e*) Brass wire gauze having a mesh of at least 20 per inch, or its equivalent, must be provided between the service pipe and the machine; the same to be secured in a substantial and rigid manner without the use of solder.

NOTE.—Lead, gas-fitters' cement, or other substances affected by gasoline and its vapor, must not be used in making joints in piping.

## CLASS C

### GASOLINE LIGHTING SYSTEMS HAVING OUTSIDE TANKS AND INSIDE FLAME-HEATED GENERATORS

These systems are regarded from an insurance viewpoint as more dangerous than the systems in Class A or Class B. Where used, their hazards should be recognized by underwriters and the following rules and precautions should be rigidly observed:

12. *Supply Tank.*—(*a*) Gasoline capacity must be limited to 6 gallons.

(*b*) To be located outside the building and so arranged that under normal conditions the only gasoline in the building will be that contained in the hollow wires leading to lamps or to the common generator.

(*c*) To be so located that no artificial light will be required while filling.

(*d*) Must be constructed of sheet copper or galvanized sheet steel not less than No. 22 U. S. gauge, securely riveted or pressed into form.

(*e*) Bushings for fill opening, outlet, and pressure gauge to be secured by locknuts or riveted.

(*f*) Seal tubes, if used, must be of brass tubing with walls not less than No. 18 B. & S. gauge, not less than $\frac{3}{4}$ inch inside diameter, and secured to fill opening bushing by an external thread not less than $\frac{3}{8}$ inch long.

(*g*) Must safely withstand a hydrostatic pressure test of 100 pounds per square inch maintained for a period of 5 minutes.

(*h*) Must be provided with a pressure gauge and a shut-off valve closing against the supply.

(*i*) Must not be operated with a pressure in excess of 50 pounds per square inch, and all tanks to be tested to this pressure by the manufacturer and so marked.

13. *Distributing Tubes—Individual Generator Systems.*—(*a*) Must be made of seamless copper or brass with an internal diameter not over .085 inch, No. 2 wire, for systems up to 10 lights and not over .125 inch, No. 1 wire, for systems with more than 10 lights, and be of sufficient thickness to safely withstand the pressure and mechanical manipulation obtained in practice. No tubing smaller than No. 2 shall be used.

(*b*) Must not be secured in place with staples. Tubes must be run in iron pipe from supply tank to inside of building wall and be protected by wooden moldings or iron pipe wherever the distance above the floor is less than 7 feet.

Must in no case be concealed behind walls or ceilings and must be protected by sleeves where passing through floors, partitions, or walls.

Must be supported in ceiling runs at intervals not exceeding 6 feet.

(*c*) When installed near electric wiring, rules of National Electrical Code to be followed. Where tubes cross wires, pipes, or metal girders, proper protection from mechanical injury to be provided.

(*d*) Tubing shall be thoroughly tested after all connections have been made, at a pressure of at least 50 pounds per square inch.

(*e*) Must be provided with readily accessible shut-off valves on each floor to control the supply of gasoline to all of the lamps on that floor, and one for each separate lamp.

(*f*) Joints must be made through solid brass fittings and must be threaded and soldered or else brazed together.

(*g*) Must have no connections depending upon gaskets, packing, or washers to prevent leakage.

14. *Distributing Pipes—Common Generator Systems.*—(*a*) Where gasoline may be discharged through the regulating valve, arrangement must

be made to prevent the discharge of the liquid into the horizontal piping of the system.

NOTE.—A properly located baffle plate will serve this purpose.

(*b*) To be secured in place with substantial metal straps or hangers at intervals not exceeding 10 feet.

NOTE.—Long screws or bolts and not nails should be used to fasten hangers in place.

(*c*) When installed near electric wiring, rules of National Electrical Code to be followed.

(*d*) Piping to be thoroughly tested after all connections have been made, so that leaks may be detected and repaired.

(*e*) All piping should be exposed, but where necessary to use concealed piping, standard full-weight, wrought-iron or steel pipe must be used. All fittings and connections for such piping to be of standard malleable iron.

NOTE.—Concealed piping must show no leak when tested to 10 pounds per square inch.

(*f*) Must be provided with readily accessible shut-off valves on each floor to control the supply of gas to all of the lamps on that floor, and one for each separate lamp.

(*g*) Must be either of brass, standard wrought iron or steel, or sheet steel galvanized, or heavy coated tin plate, 160-pound American Bas-Box, with an internal diameter not greater than 2 inches.

Sheet steel pipes to be not less than No. 26 U. S. gauge before coating (.019 inch), with locked longitudinal seams thoroughly sweated with solder, or galvanized after forming.

(*h*) All connections must be made through substantial fittings. Slip joints not allowed, except by special permission when installed under supervision of underwriters having jurisdiction.

NOTE.—Connections should be so made and attached that the piping may be installed with lamps in proper alignment without the necessity of impairing the tightness of the joint.

(*i*) Must have no connections depending upon gaskets, packing, or washers to prevent leakage.

(*j*) Gasoline connection between supply tank and generator to be made of material and installed in a manner similar to that required for distributing tubes for individual generator systems.

15. *Lamps—Installation.*—(*a*) Not to be used in places where an undue amount of ignitable material may accumulate on them, or where there is inflammable dust or gas, or where there is loose inflammable material on the floor under them.

(*b*) Lamps of individual generator systems to be supported by a metal ceiling plate held by long screws or bolts and must not depend upon tubing for support.

NOTE.—Where lamps must be installed between joists means should be provided to rigidly support each lamp from the two nearest joists.

(*c*) Lamps of common generator systems to be rigidly fastened to the piping, independently of solder used to secure tightness against leakage. A substantial ceiling plate to be provided so that the lamp may be rigidly secured by long screws or bolts and not depend upon brass or sheet metal pipe for support.

NOTE.—Where it is necessary to install lamps between joists, an acceptable alternative is to use two pipe supports such as are specified in 14 (*a*); these supports to be placed on the piping on opposite sides of the lamp and secured, in the manner previously specified, to the joists nearest to the lamp.

LAMPS—INDIVIDUAL GENERATOR SYSTEMS

16. *Frames.*—(*a*) Must be rigid and have ample strength for supporting the several parts of the lamp.

(*b*) Must be connected together and to the other parts of the lamp by threaded or brazed joints.

(*c*) Must be of such length that the distance between the burner gauze and the top of the frame shall not be less than 20 inches.

(*d*) All parts used for conveying gasoline must be constructed of brass with threaded joints.

17. *Generators.*—(*a*) Must be rigid and constructed of brass or copper where contact is made with gasoline or its vapor.

(*b*) Must in no part have walls less than $\frac{1}{32}$ inch in thickness.

(*c*) Must have all joints threaded or brazed. Threaded joints must not depend upon a filler for tightness.

(*d*) Plugs used for filling drill holes must be threaded, and if made removable, must have a beveled end and set up tight against a seat.

(*e*) Must have a projecting sleeve or shield across the space between the gas tip and air-mixing chamber.

(*f*) Must have all parts accessible for purposes of cleaning or repairs.

(*g*) Must have sufficient metal to hold heat and maintain generation under all conditions of use, independent of the mantle.

NOTE.—Generators in which a sub-flame is used are preferable.

(*h*) Generator must not be initially heated by the use of liquid gasoline.

18. *Valves.*—(*a*) Shut-off valves must be made of brass, close against the supply, and have a steel or phosphor-bronze stem provided with a stuffing cap.

(*b*) Regulating or cleaning valves must have a straight needle, or be provided with a stop on the stem to prevent the needle from enlarging the gas tip.

NOTE.—The regulating or cleaning valve must in no case be used for a shut-off.

19. *Auxiliary Parts.*—(*a*) Metal heat deflectors must be not less than 4 inches in diameter, and must be secured in a substantial manner so as not to be readily removed.

(*b*) Strainers must be provided, through which the gasoline must pass before reaching the shut-off valve. The strainer should be a separate fitting, removable for the purpose of cleaning.

(*c*) Burner gauzes to be of substantial construction, preferably of German silver.

(*d*) Every lamp must be provided with a metal name plate giving the name of lamp and the name and address of its manufacturer.

LAMPS—COMMON GENERATOR SYSTEMS

20. *Frames.*—(*a*) Must be rigid and have ample strength for supporting the several parts of the lamp.

(*b*) Must be connected together and to the other parts of the lamp by threaded joints.

(*c*) When of the upright-mantle type, must be of such a length that the distance between the burner gauze and the ceiling shall be not less than 24 inches.

(*d*) When of the inverted-mantle type, must be of such a length that the distance between the burner gauze and the ceiling shall be not less than 15 inches.

NOTE.—Where necessary, adequate protection must be afforded against the hazard of falling broken mantles or other incandescent particles.

(*e*) All parts used for conveying gas must be constructed of brass or galvanized iron or steel.

21. *Valves.*—Shut-off valves must be made of brass, and must be capable of completely extinguishing the flame of the burner and so arranged as to prevent the hazards of condensation.

NOTE.—When the distribution piping is led through rooms where low temperatures are liable to occur there is a possibility of condensation accumulating in the lamp and, in case the valve is absolutely tight, causing the discharge of the condensation on the operator when the lamp is being lighted. This may be obviated in such locations by the use of a special form of fixture or by having the valve so made that such condensation will gradually escape and evaporate.

22. *Auxiliary Parts.*—(*a*) Metal heat deflectors must be not less than 6 inches in diameter, and must be secured in a substantial manner so as not to be readily removed.

(*b*) Burner gauzes to be of substantial construction, preferably of German silver.

(*c*) Lamps having inverted mantles must be provided with a substantial casting for catching and holding condensation. This casting to be located not over 6 inches above the burner and to be below any smoke bell or heat deflector.

(*d*) Every lamp must be provided with a metal name plate giving the name of lamp and the name and address of its manufacturer.

GENERATORS—COMMON GENERATOR SYSTEMS

23. *Generator and Case.*—(*a*) Must be enclosed in an approved metal case having double walls, between which an air space of not less than 1 inch is maintained, circulation of air between these walls to be secured by perforated top and bottom of outer case. A drip pan ½ inch deep must be provided in bottom of inner case.

The case must be provided with a hinged metal door secured by a latch.

(*b*) To be installed in such a manner that a clear space is maintained above and below from floor to ceiling and for at least 1 foot on either side of the generator case.

(*c*) Case to be fastened to iron brackets rigidly secured to the wall of the building.

(*d*) Generator must not be initially heated by the use of liquid gasoline.

(*e*) Must be constructed of brass or copper where contact is made with gasoline or its vapor.

(*f*) Must in no part have walls less than $\frac{1}{16}$ inch in thickness.

(*g*) Must have all joints threaded and not depend upon a filler for tightness.

(*h*) Plugs used for filling drill holes must be threaded, and if made removable must have a beveled end and set up tight against a seat.

(*i*) Must have all parts accessible for purposes of cleaning or repairs.

(*j*) Must have sufficient metal to hold heat and maintain generation under all conditions of use.

NOTE.—Generators in which a sub-flame is used are preferred.

(*k*) Must be provided with a shut-off valve made of brass, closing against the supply and having a steel or phosphor-bronze stem provided with a stuffing cap.

(*l*) Regulating or cleaning valves must have a straight needle, or be provided with a stop on the stem to prevent the needle from enlarging the gas tip.

NOTE.—The regulating or cleaning valve must in no case be used for a shut-off.

(*m*) Strainers must be provided, through which the gasoline must pass before reaching the shut-off valve. The strainer should be a separate fitting, removable for the purpose of cleaning.

24. *Air Intake*.—(*a*) Must be of standard wrought-iron or heavy brass tubing.

(*b*) Must be carried untrapped to outside of building, with a downward pitch of not less than 1 inch in 3 feet.

(*c*) Must be provided with a hood at outer end.

NOTE.—A substantial elbow turned open end down and provided with a brass gauze is recommended.

(*d*) Must be secured to generator by threads, and at such a point that all parts of the mixing tube will be drained.

## CLASS D

### GASOLINE VAPOR LAMPS

These lamps are regarded from an insurance viewpoint as even more dangerous than the systems covered in Class A, Class B, or Class C, and where used, their hazards should be recognized. If permitted, the follow-

ing general specifications for the construction of such devices and for regulating same should be observed.

25. *Frame.*—See Rule 16.

26. *Reservoirs—For Gravity Lamps.*—(*a*) Must be constructed of brass or copper of at least No. 26 B. & S. gauge, and must measure when finished not less than No. 28 B. & S. gauge in thickness.

NOTE.—Care must be taken that unncessary drawing of the metal is not caused by the process of spinning or stamping and that metal blanks of sufficient size are used.

(*b*) Must not exceed 2 quarts capacity.

(*c*) Must be supported at the bottom and be so constructed that no joints will be dependent upon solder alone.

(*d*) Must be provided with a conspicuous filling indicator to show when reservoir is nearly full, and thus avoid overfilling and spilling of gasoline.

NOTE.—Reservoirs with a removable fount are preferred, as filling may be done away from the lamp and the spilling of gasoline over the frame is avoided.

*For Pressure Lamps.*—(*e*) Must be constructed of brass of at least No. 18 B. & S. gauge, and must measure when finished not less than No. 20 B. & S. gauge in thickness.

NOTE.—Care must be taken that unnecessary drawing of the metal is not caused by the process of spinning or stamping and that metal blanks of sufficient size are used.

(*f*) Must be arranged so that not to exceed 2 quarts of gasoline may be supplied.

NOTE.—It is recommended that reservoirs be made spherical in form and of such size that a seal tube projecting inward to the center will limit the capacity to 2 quarts.

(*g*) Must safely withstand the following tests:

1. An intermittent hydrostatic pressure test lasting 1 hour with a pressure of 100 pounds per square inch on for 5-minute periods and off for 1-minute periods during the hour.

2. A constant hydrostatic pressure test of 200 pounds per square inch maintained for a period of 5 minutes.

27. *Generators.*—See Rule 17.

28. *Valves.*—(*a*) Shut-off valves must be made of brass and have a steel stem provided with a stuffing cap.

(*b*) Shut-off valves must close against the gasoline supply and in gravity-feed lamps be so placed that the lamp will not continue burning more than 1 minute after the valve is closed.

(*c*) Regulating or cleaning valves must have a straight needle or be provided with a stop on the stem to prevent the needle from enlarging the gas tip.

NOTE.—The regulating or cleaning valve must in no case be used for a shut-off.

29. *Auxiliary Parts.*—(*a*) Metal heat deflectors must be attached to all pressure-feed lamps and to all gravity-feed lamps and fixtures in which

the distance from the burner gauze to the top of the frame is less than 30 inches, or in which the distance between the edge of the reservoir and the vertical center line of the generator is less than 6 inches.

(*b*) Metal heat deflectors must be not less than 4 inches in diameter, and must be secured in a substantial manner so as not to be readily removed.

(*c*) Strainers should be provided, through which the gasoline must pass before reaching the shut-off valve. The strainer should be a separate fitting, removable for the purpose of cleaning.

NOTE.—In pressure lamps a filter funnel will be accepted where the construction is such that a removable filter cannot readily be provided.

(*d*) Each lamp must be provided with a name plate or stamp, giving the name of the lamp and the name and address of its manufacturer.

## CLASS E

### SYSTEMS HAVING INSIDE TANKS AND INSIDE FLAME-HEATED GENERATORS

These systems, which embody the hazard of handling gasoline inside buildings, are regarded from an insurance viewpoint as more dangerous than the devices covered in Class A, Class B, or Class C, and on a par with those of Class D. When used, their hazards should be recognized.

If permitted, the following general specifications for the construction of such devices and for regulating same should be observed.

30. *Supply Tank.*—(*a*) Gasoline capacity not to exceed 6 gallons.

(*b*) Should preferably be located against an outside wall and so installed that a clear space is maintained above and below from floor to ceiling, and for at least 1 foot on either side of the device.

NOTE.—Where located against other than a fireproof wall, to be insulated therefrom by an ample sheet of metal placed not less than 1 inch from the wall, leaving an air space.

(*c*) To be located so that no artificial light will be required while filling or cleaning and as far removed as possible, in no case less than 10 feet, from any stove or furnace, and preferably not below grade level.

(*d*) Must be constructed of copper, brass, or steel galvanized after forming and must be of sufficient strength to withstand a hydrostatic pressure of 350 pounds held for 1 minute without showing signs of distortion or strain, and a pressure of 500 pounds before bursting. Thickness of copper and brass to be not less than No. 18 B. & S. gauge (.040 inch), and of steel to be not less than No. 16 U. S. Standard gauge (.062 inch).

NOTE.—All tanks must be tested by manufacturer to 350 pounds and so marked.

(*e*) No joints or seams of tank, fittings, or bushings for fittings to depend upon solder for strength or tightness.

(*f*) All openings in tank must be so arranged that under normal conditions gasoline cannot be forced from tank into building, and so that any vapor under pressure in the tank will be forced to outside of building before fill plug can be removed.

(*g*) Tank to be filled only with an approved special filling can supplied by manufacturer, and constructed in accordance with the National Board specifications for safety cans. This can must be so made that the tank cannot be overfilled and so that a proper air space will be maintained in the tank above the gasoline level.

(*h*) All supplies of gasoline to be kept outside of building, together with the filling can, except when the can is being actually used in filling the tank.

(*i*) The tank must not be subjected to an operating pressure in excess of 50 pounds per square inch, and, unless the pressure is automatically controlled, must be provided with a pressure gauge.

(*j*) In machines of a type in which the pressure is cumulative the operating pressure must be automatically controlled.

31. *Pressure Relief.*—(*a*) Tank must be provided with a pressure relief which does not depend on solder for operation or tightness against leakage, and which will automatically release any pressure in excess of 100 pounds per square inch.

(*b*) This pressure relief must not depend on parts, the corrosion of which would render the device inoperative.

(*c*) If thin sheet-metal diaphragms are used in the pressure relief, they must be so arranged as to avoid the insertion of more than one in the fitting.

(*d*) Must be provided with standard galvanized wrought-iron or steel escape pipe, not less than $\frac{3}{8}$-inch pipe size, which is carried untrapped to the outside of building with a downward pitch of not less than 1 inch in 3 feet.

NOTE.—This pipe, which may also be used for the relief referred to in Rule 30 (*f*), should not terminate near any opening into a lower part of the building or over any areaways where vapors could collect.

(*e*) Escape pipe must be provided at the outer end with a weatherproof hood containing a properly protected screen of non-corrodible metal.

32. *Generators.*—(*a*) Must be enclosed in an approved metal case having double walls, between which an air space of not less than 1 inch is maintained; circulation of air between these walls to be secured by perforations near top and bottom of outer casing. The case must be provided with a substantial, hinged, metal door secured by a latch.

NOTE.—Where gasoline may escape from any stuffing cap, or where alcohol is used for initial generation, a drip pan $\frac{1}{2}$ inch deep must be provided in the bottom of the case; but where gasoline cannot escape and alcohol is not used, this pan may be omitted and increased ventilation obtained by constructing the case without a bottom.

(*b*) Rule 30 (*b*) and (*c*) for tank should be closely followed, and, when the generator is closely connected to tank, ample means should be provided to prevent injury to the system due to unequal expansion of the parts.

(*c*) Both tank and generator to be rigidly supported by substantial iron brackets held by long screws or bolts, or by substantial iron stands secured to the floor.

NOTE.—The floor underneath the generator and tank and the wall against which they are placed should be protected against the absorption of oil, by a sheet-metal pan and shield. Pan to have substantial turned up edges.

(*d*) Generator must not be initially heated by the use of liquid gasoline.

(*e*) Must be constructed of a suitable alloy which is not affected by gasoline or its vapor under any condition of use.

(*f*) Must in no part have walls less than $\frac{1}{16}$ inch in thickness.

(*g*) Must have all joints threaded, brazed, or otherwise secured so as not to depend on a filler for tightness.

(*h*) Plugs, if made removable, must have a beveled end, or shoulder, and set up tight against a beveled seat.

(*i*) All parts must be accessible for cleaning or repairs.

(*j*) Generator must be constructed so that generation will be maintained under all normal conditions of use.

(*k*) Valves should close against the supply, and, in case they do not, must be provided with a stuffingbox containing a cupped follower gland.

(*l*) Valve must have either a steel or phosphor-bronze stem, and where used as a regulating or cleaning valve, must be so arranged that the orifice of the gas tip will not be enlarged.

33. *Air Intake.*—(*a*) Except where liquid gasoline cannot be forced from the controlling valves, to be carried untrapped to the outside of building, with a downward pitch of not less than 1 inch in 3 feet.

(*b*) Intake pipe must be of standard wrought iron or steel or of brass, with the exception above noted, and must be secured to generator by threads at such a point as to drain all parts of the device which might become flooded with gasoline.

(*c*) In all cases where gasoline may be discharged from the air intake it must be provided with a substantial hood containing a properly protected non-corrodible screen, about 20 mesh per inch.

NOTE.—This pipe should not terminate near any opening into a lower part of the building or over any areaway where vapors could collect.

34. *Auxiliary Parts.*—(*a*) All pumps permanently connected with tanks to be installed in a horizontal position to prevent collection of condensation.

(*b*) All valves which control either gasoline or its vapor to be so arranged that valve stem cannot be withdrawn by continuing the opening motion.

35. *Distributing Pipes.*)—See Rule 14.

36. *Lamps:—Installation.*—See Rule 15.

37. *Frames.*—See Rule 20.

38. *Valves.*—See Rule 21.

**79. Construction of Appliances.**—The preceding rules give only a partial outline of the Board's requirements regarding the design or construction of appliances. Before being introduced for use, all appliances should be submitted to the underwriters' laboratories for examination, test, and report.

## BLAU GAS

**80.** In districts not reached by gas mains or in buildings not equipped with acetylene- or gasoline-gas machines, and in buildings equipped temporarily, also in factories and industrial buildings where gas is used for brazing, welding, etc. in addition to illumination, a Blau gas equipment may be used.

**81.** Blau gas is a mixture of hydrocarbon gases that, under ordinary pressure and temperature, are in a gaseous form, but that will liquefy under high pressures and low temperatures. These so liquefied hydrocarbons contain, absorbed or dissolved therein, under the pressure and temperatures employed in the Blau process, a large quantity of the nearly related gases and a small quantity of the so-called permanent gases, especially methane and hydrogen, the whole forming an aggregate of hydrocarbons which, under high pressure and normal temperature, remains a liquid, but which, when released to nearly atmospheric pressure and normal temperature, will be reconverted into a gaseous aggregate.

**82. Manufacture of Blau Gas.**—Ordinary gas oil, crude oil, fuel oil or any similar agent is distilled in retorts in the usual manner. The gas produced thereby is conducted through coolers and scrubbers for the purpose of removing the tar. From there it passes through receptacles containing chemical cleansing agents that remove the impurities, such as sulphide of hydrogen, carbon dioxide, etc. The gas is then collected in gas holders. From these gas holders it is withdrawn, cooled, and compressed. Certain hydrocarbons, especially those that would liquefy under ordinary pressure and temperature, are withdrawn. The remaining gases are subjected to continually increasing pressure, the final stage of compression being about 100 atmospheres, whereby a large quantity of the hydrocarbons will liquefy. These liquefied hydrocarbons will absorb a considerable quantity of those hydrocarbons which, under the pressure and temperature employed, will not liquefy, and they will also absorb a small

quantity of the so-called permanent gases, especially methane and hydrogen. These so liquefied and absorbed gases are conducted into strong steel bottles or cylinders, in which they are shipped to the consumer, like the cylinders of carbonic-acid gas so extensively sold to druggists. The Blau gas so produced has been reduced to $\frac{1}{400}$ of its volume. In other words, 1 cubic foot of the liquefied gas, on escaping from the bottle, will expand to 400 cubic feet of gas ready for combustion at the burners.

**83.** As produced by the process just described Blau gas contains a large quantity of the heavier hydrocarbons and a relatively small quantity of the permanent gases; therefore, it is rich in heat value. One cubic foot of Blau gas yields about 1,800 British thermal units as against about 650 per cubic foot of ordinary coal gas. Therefore, Blau gas is better than coal gas for brazing or welding purposes and is consequently useful in laboratories, factories, etc.

Each pound of liquid gas will yield about 12½ cubic feet of expanded gas. To make an explosive mixture, the following amounts of gas are required to be mixed with air: Coal gas, 6⅓ per cent.; Blau gas, 4 per cent.; acetylene gas, 2 per cent.

**84.** A Blau-gas equipment is shown in Fig. 16. The steel bottle $a$ is connected up and in service. The bottle $a'$ is a new one being set in place to replace the empty bottle $a''$ just removed. After the new bottle $a'$ is connected up the doors are locked.

The equipment consists mainly of the steel bottles which contain the liquid gas, only one bottle being used at a time. From the bottles the gas flows through the pressure-regulating valve $b$ into the expansion tank $c$, where the liquid, on account of the reduction in pressure, expands into gas. From the tank $c$ the gas flows through a more sensitive pressure-reducing valve $d$ into the service pipe $e$, which feeds the house distributing pipes. The gauge $g$ registers the pressure in the expansion tank. The gas is not affected by weather conditions, and will keep indefinitely.

The gas is shipped in the bottles *a*, each of which contains from 20 to 25 pounds of liquid gas. When the bottles are emptied they can be returned to the factory to be recharged. The manufacturers also furnish with the apparatus a steel cabinet *f* that may be set outdoors, as the gas will not freeze or condense in the pipes.

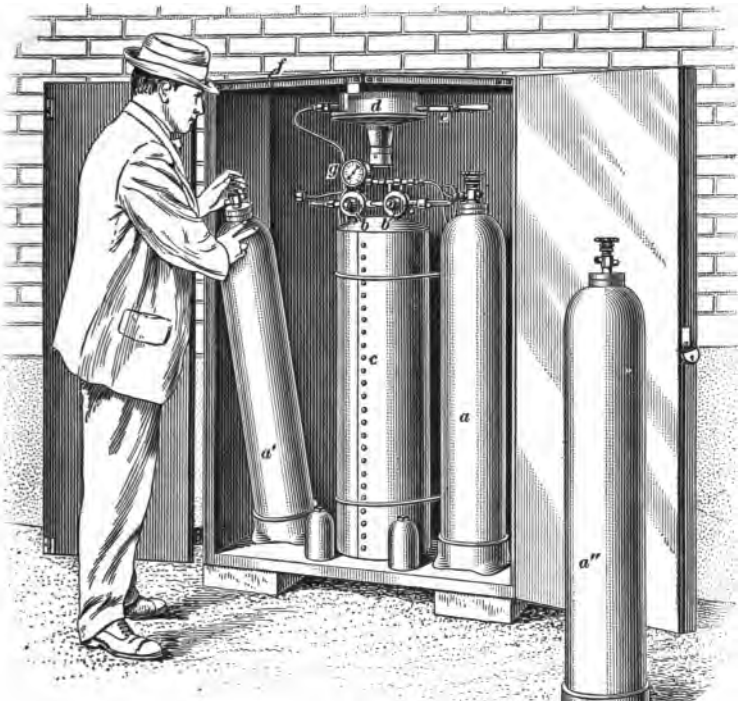


Fig. 16

Ordinary piping that has been installed for coal or acetylene gas may be used for Blau gas. By applying special burners this gas can be used in any of the gas appliances on the market; but for lighting purposes, on account of its high heat value, suitable mantles such as Welsbach are recommended.

Blau gas produces a light which, in color and brilliancy, approaches as near as possible that of the sunlight. It is non-poisonous, and therefore cannot asphyxiate.

## NATURAL GAS

**85.** Natural gas is obtained from holes or wells that are drilled in the earth. It is found in large quantities in the vicinity of deposits of petroleum; and deposits of coal, both bituminous and anthracite, are always accompanied by greater or less quantities of gas of a very similar nature.

It is composed mainly of a compound of carbon and hydrogen and is called *light carbureted hydrogen.* This often amounts to 90 per cent. or more of the total volume. Consequently, it will develop more heat per cubic foot in burning than ordinary gas.

Natural gas is produced at the wells under great pressure, and in common practice the pressure in the street mains and distributing pipes is allowed to be very much higher than is usual with manufactured gas.

**86. Uses.**—Natural gas may be used for any of the purposes for which manufactured gas is used, and in a great many places, on account of its relatively low cost, it is extensively used for heating buildings and for industrial purposes. As compared with manufactured gas, it is necessary to have specially drilled burners, and it is also necessary to have the gas apparatus made much stronger in order to stand the intense heat.

The illuminating power of natural gas by an open burner is far below that of coal gas, but it can be improved by carbureting. Owing to the intense heat from natural-gas flames, excellent lighting results are obtained by special burners and mantles of the Welsbach type.

**87. Pipe Sizes for Natural Gas.**—The pipe sizes used for natural gas are based on the number of fires and lighting burners, each fire consuming between 50 and 75 cubic feet per hour, and each burner from 6 to 10 cubic feet per hour.

The ordinary practice is to use a $\frac{1}{2}$-inch pipe for small portable fires, a $\frac{3}{4}$-inch pipe for kitchen ranges, etc., and for a furnace in an ordinary ten-room house a $1\frac{1}{2}$-inch pipe line is usually installed.

**88. Distribution of Natural Gas.**—The distribution of natural gas from the high-pressure wells to the buildings where the gas is consumed at a very low pressure is principally a matter of pressure reduction, by the use of suitable pressure-reducing valves at the well and of sensitive pressure regulators in the buildings. The pressure at the well is of course variable, but frequently very high, sometimes being over 1,000 pounds to the square inch. The pressure desired

TABLE I

CAPACITY OF NATURAL-GAS PIPES

| Nominal Diameter of Pipe Inches | Maximum Length Feet | Number of Fires |
|---|---|---|
| $\frac{3}{8}$ | 6 | 1 |
| $\frac{1}{2}$ | 20 | 1 |
| | 4 | 2 |
| $\frac{3}{4}$ | 60 | 1 |
| | 20 | 3 |
| 1 | 125 | 1 |
| | 15 | 5 |
| $1\frac{1}{4}$ | 350 | 1 |
| | 30 | 8 |
| $1\frac{1}{2}$ | 275 | 3 |
| | 25 | 12 |
| 2 | 600 | 2 |
| | 40 | 12 |

in the street mains varies with the local conditions, being frequently between 10 and 40 pounds per square inch The pressure required in the buildings where the gas is consumed varies somewhat with the conditions. For instance, if it is used for firing boilers or furnaces in factories the pressure may be $\frac{1}{4}$ or $\frac{1}{2}$ pound or higher if necessary for the work; but for residence use the pressure usually is from 2 to 4 inches water column; but whatever pressure is finally determined

upon for the building, the pressure governor in the building must hold it steadily at that.

The pressure-reducing valve required to drop the gas pressure the first stage from the well pressure to the street pressure is placed at the well. Fig. 17 shows how this may be done. The gas pipe *a* coming up through the ground is furnished with a pressure gauge *b*, which shows at all times the initial pressure of the gas at the well. A valve is located at *c* on the pipe that supplies the street mains from the well. This is for the control of the entire service. A gas furnace is located at *d* to heat the gas so that when it is reduced in pressure it will not freeze. Another gauge is placed at *e* to indicate the pressure before it is reduced. At *f* are gate valves for controlling the gas at the reducing valve *g*.

The pressure in the street mains is raised or lowered by changing the counterweights shown on the lever of this pressure-reducing valve. The pressure in the street main is indicated by the pressure gauge *h*. This pressure-reducing apparatus is composed of a balanced valve in the body of *g* communicating with a stem with a diaphragm in the upper chamber, the lever and counterweight being arranged to raise and lower the valve stem according to the pressure on top of the diaphragm. The space above the diaphragm communicates with the street mains or low-pressure side of the pressure-reducing valve by the pipe shown at *i*. A safety valve *j* is placed on the street-main side of the pressure-reducing valve to prevent the pressure in the street mains from rising too high, should the pressure-reducing valve *g* get out of order. This safety valve is piped to the outer atmosphere. The pipe *k* continues and connects to the street mains under ground, and the pipe *l* supplies gas to the burner in the furnace *d*.

**89.** A **house regulator** for a natural-gas service pipe is shown in Fig. 18. The inlet nipple *a*, which is provided with a filter screen at the mouth, connects to the underground main. The pipe *b* connects the outlet of the regulator to the house pipes; therefore, *a* is the high-pressure end and *b* the

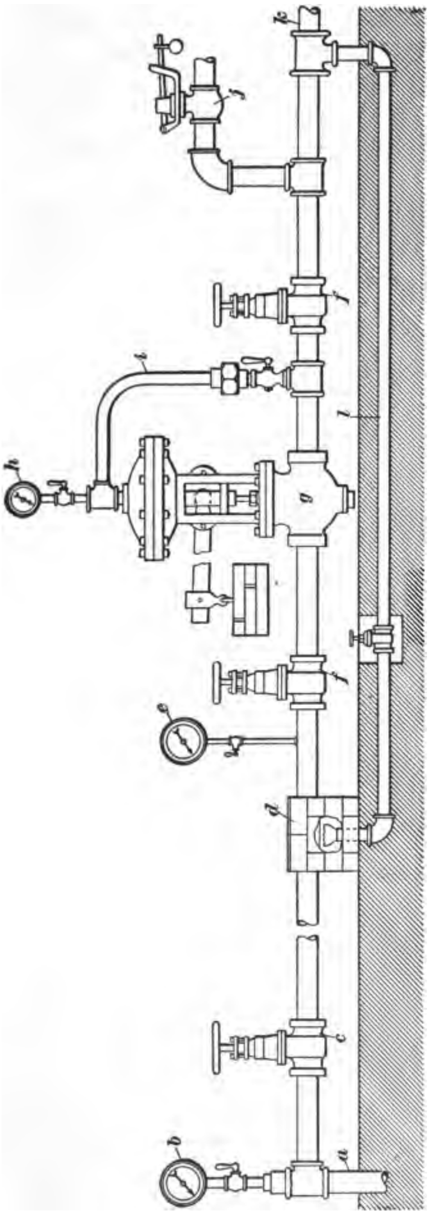

Fig. 17

low-pressure end. The object of this regulator is to maintain a uniformly low pressure in *b*, independent of the higher pressure and its fluctuations in *a*. The high-pressure reducing valve *g*, in Fig. 17, operates on the same principle as that in Fig. 18, except that in Fig. 17 it is provided with a balance valve, whereas in Fig. 18 it is provided with a single lifting valve *c*. This valve is rigidly attached by a rod and stem to the diaphragm *d*, and the weighted lever *e*, which is pivoted at *f*, engages with the stem of the valve and diaphragm. The chamber above the diaphragm *d* communicates by means of a pipe *g* with the house-service pipe *b*, so that whatever pressure is in *b* will exist on top of the diaphragm *d*. The under side of the diaphragm, however, is subject to the pressure of the atmosphere all the

time and this does not change. Therefore, if the weight *h* is set on the lever so that a gas pressure in *b* equal to, say, 4 inches of water column, will counterbalance *h*, then the valve *c* will open when gas is drawn in the house, and immediately close when it is shut off, and will maintain a uniform pressure in *b*.

A dead-weight safety valve is located at *i* and is set to blow off at a pressure a little higher than that maintained in the gas-distributing pipes *b*. This safety valve is piped

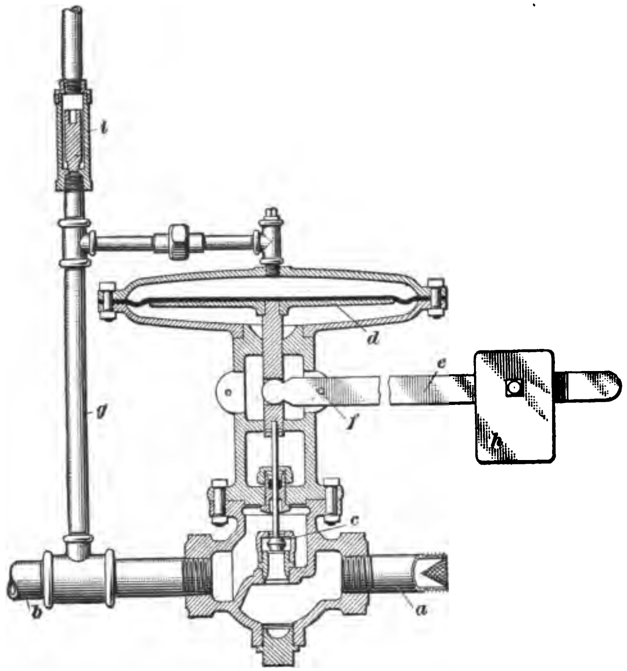


FIG. 18

up through the roof to the outer atmosphere, and allows surplus gas to escape rather than increase the pressure in the system or burst the diaphragm, should the valve *c* get out of order and leak. A pressure regulator of this or some other type should always be placed on the service to a building supplied with natural gas where there is any liability of the pressure increasing to a dangerous point at any time.

# GAS SUPPLY AND DISTRIBUTION
(PART 1)

## GAS SUPPLY

### GAS PIPES AND FITTINGS

#### CAST-IRON GAS PIPE

**1.** The pipes used for the distribution of gas are made of different materials, such as cast and wrought iron, brass, lead, block tin, and composition which is an alloy of lead, tin, and antimony; they are also made of rubber.

The main gas-supply pipes that are laid in the streets are called **mains.**

Branches that conduct gas from the mains to the house are called **service pipes** or *services*.

Pipes that convey the gas from the meter to the various parts of the building are called **distributing pipes.**

Vertical pipes are called **risers** or *drop pipes*, according to the direction of the flow of gas within them. The flow is upwards in a riser and downwards in a drop pipe.

**2. Quality and Sizes.**—Cast iron is usually employed for large pipes that are to be buried in the ground, such as street mains and service pipes. The pipes made of this material are liable to be of uneven density and texture, being close grained and hard in some parts and coarse grained and spongy in others. They are liable, also, to be perforated by blowholes

and bubbles, which vary in size from minute pinholes to hollow spaces as large as the hand, having only a thin crust of metal on the inside and outside of the pipe. To detect these defects, all cast-iron pipe should be thoroughly inspected at the foundry where it is made. The presence of unsound iron or spongy places, or bubbles of any considerable size, will be revealed by the difference in the sound when tapped with a light hammer. Each pipe should also be subjected to a test by hydraulic pressure, to prove its tightness and strength.

**3.** If the grain of the iron is coarse and soft, the gas will gradually exude through the metal and leak away, although the pipe may be strong and solid. While this defect can be remedied in water pipe by coating the pipe thoroughly both inside and outside with asphaltum or a mixture of asphaltum and tar, such a coating is useless for gas pipe, as the gas will dissolve the tar or asphaltum and then leak out. Such a coating on gas pipe is of value only in preventing rust; in the case of cast-iron pipe, such a precaution is unnecessary in ordinary soils.

Where coated pipe is used, the proper method of applying the coating is to dip the previously tested pipe while hot in a bath of melted asphalt or tar. If the metal is not properly heated, the coating will not adhere with sufficient firmness and will fail to penetrate and seal the small defects in the pipe. The standard cast-iron gas pipes on the market are usually uncoated.

When coated pipe is used for gas mains, both the bell and spigot ends should be heated in a fire until all the tar or asphaltum has been burned off; for, if the joint is made up with the coating on, the gas will dissolve the thin film left between the pipe and the lead or cement used to make the joint, and a leak will occur.

**4.** The standard sizes and weights of cast-iron gas pipe are given in Table I, which is taken from Kent's Mechanical Engineers' Pocketbook. The standard length of all sizes is 12 feet, except 2-inch pipe, which is 8 feet long. The size of cast-iron gas pipe is designated by the actual internal diameter.

**5. Trenches and Drip Pot.**—Gas mains and service pipes are generally placed in trenches dug to receive them. In order to afford room for working at the joints, holes must be excavated wherever a joint occurs, that is, at intervals of

**TABLE I**

**STANDARD CAST-IRON GAS PIPE**

| Size Inches | Weight per Foot Pounds | Weight per Length Pounds | Thickness Inches |
|---|---|---|---|
| 2 | 6 | 48 | $\frac{1}{4}$ |
| 3 | $12\frac{1}{2}$ | 150 | $\frac{5}{16}$ |
| 4 | 17 | 204 | $\frac{3}{8}$ |
| 6 | 30 | 360 | $\frac{7}{16}$ |
| 8 | 40 | 480 | $\frac{7}{16}$ |
| 10 | 50 | 600 | $\frac{7}{16}$ |
| 12 | 70 | 840 | $\frac{1}{2}$ |
| 14 | 84 | 1,000 | $\frac{9}{16}$ |
| 16 | 100 | 1,200 | $\frac{9}{16}$ |
| 18 | 134 | 1,600 | $\frac{11}{16}$ |
| 20 | 150 | 1,800 | $\frac{11}{16}$ |
| 24 | 184 | 2,200 | $\frac{3}{4}$ |
| 30 | 250 | 3,000 | $\frac{3}{4}$ |
| 36 | 350 | 4,200 | $\frac{7}{8}$ |
| 42 | 417 | 5,000 | $\frac{15}{16}$ |
| 48 | 542 | 6,500 | $1\frac{1}{8}$ |
| 60 | 900 | 10,800 | $1\frac{3}{8}$ |
| 72 | 1,250 | 15,000 | $1\frac{1}{2}$ |

12 feet for all sizes of pipe above 2 inches, and 8 feet apart for 2-inch pipe. These holes are known as *bell holes*.

The ground between the bell holes should be leveled smooth to carry the weight of the pipe evenly; where the soil is soft or marshy, pieces of board should be placed across the ditch to help carry the weight of the pipe. If any filling is required in the ditch, in order that the pipe may be firmly bedded,

the earth under the pipe should be tamped thoroughly. If the above precautions are not taken, the pipe may settle and broken mains or leaky joints may result; also, the pipes may sag so as to form a trap in which water will collect and partially or entirely shut off the flow of gas.

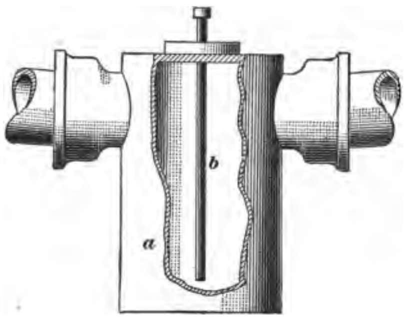

FIG. 1

**6.** All gas mains must be laid in perfect alinement without sags, and at every low point a drip pot must be set. Fig. 1 shows an ordinary drip pot. It is composed of a large iron vessel *a* about the size of a barrel. A small pipe *b* is run from the top of the ground down inside the pot, so that the condensation that is sure to accumulate can be pumped out.

**7. Joints.**—Cast-iron gas pipe is jointed by either lead or cement joints; lead joints are most commonly used.

A lead joint in a gas main lying in a trench is shown in Fig. 2. To make the joint, the spigot end of the pipe is lifted up after it has been placed into the *bell*, as the socket is often called, of the next length of pipe. A piece of twisted hemp,

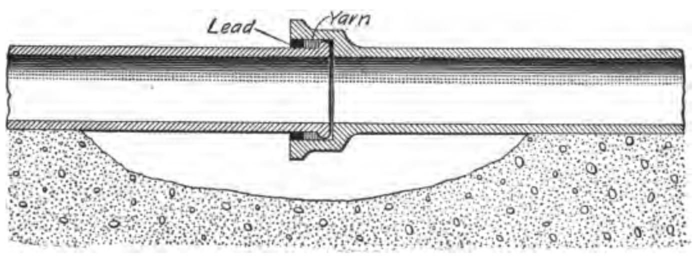

FIG. 2

about $\frac{3}{4}$ inch in diameter and a little longer than the circumference of the pipe, is pushed into the bell in such a way that it completely surrounds the spigot end. The spigot end is

then pushed home in the bell and the hemp is driven back solidly around the pipe with a yarning iron or staving tool. More yarn is then driven in around the pipe until only about 1½ inches of the bell is left clear. A joint runner is now clamped around the pipe close to the bell, and any openings between it and the bell are closed up with clay. An opening or pouring gate is left at the top, through which melted lead is poured until the bell is completely filled. The lead should be just hot enough to run freely and should be poured in from an iron ladle large enough to run the whole joint at one pouring. When two ladlefuls are required, a second ladle should be held ready to begin pouring the instant the first one is empty, to insure a proper adhesion of the lead in the bell. If no joint runner is at hand, a piece of yarn coated thickly with tough clay forms a very good substitute. Such a joint runner is frequently called a *snake*. Where the pipe is a little wet, some oil, such as machine oil, should be poured into the joint before it is run. This will prevent the spattering of lead and will insure a good joint. The lead will cool in 2 or 3 minutes. The joint runner should then be removed and the joint examined carefully, especially at the under side. If the lead has not run in evenly all around and filled the joint properly, it should be cut or burned out and a new joint run.

If the joint has filled out nicely, the lead should be cut with a cold chisel where it may have run out in small leaks, and at the top, where a large block will be left at the point the lead was poured in. The lead should then be driven back all around at the junction of the pipe and lead with a cold chisel and a short heavy hammer, and then the whole surface of the lead joint should be driven up evenly and smoothly with a hammer and a calking iron. Calking irons are made with faces of different sizes, to facilitate the calking of joints of different widths. Great care should be taken in calking to make thoroughly tight joints, as bad joints are a prevalent cause of leakage.

**8.** Cement joints are made as follows: After placing the cast-iron gas pipes in the trench and tamping the ground

around them thoroughly so that they cannot settle or be moved out of alinement, as much of them as possible is covered without allowing dirt to fall into the bell holes, and after the pipe layers are far enough ahead of the joint makers, the making of cement joints can be begun.

The cement is made by mixing Portland cement with water, and just enough cement for two or three joints is made up at a time if there is but one man making joints. The mixing should be done by a helper, who should keep the mixture stirred constantly to prevent initial setting. No sand should be used, only the clear cement, and it should be used in a plastic condition.

In making the joint, the yarn should be first soaked in thin cement and then driven back in the bell and followed up immediately with the cement, which is placed in the bell and pushed back with the right hand. The hand should be protected by a rubber mitten, because cement is injurious to the hands. Cement cannot be pushed back successfully with a trowel or other such tool.

It is useless to put on more cement than is required to just fill the bell, and it should be faced perfectly smooth with a trowel. The joint should be immediately covered with a wet cloth to supply the cement with moisture to prevent it from setting too quick, and to keep the temperature low. By covering the pipes with dirt previous to making the joints, and by boarding over the joints, the temperature of the pipe line does not change sufficiently to injure the joints. If the day is hot, and the sun shines on any part of the pipe or joint, boards should be placed over the joint to intercept the sun's rays.

**9.** Tests for leaks should not be applied until at least 3 hours after the joints have been made. The test should be made with an air pump; the pressure need not exceed $\frac{1}{2}$ pound, as leaks might be made by a greater pressure. After the joints are thoroughly set, they will stand a higher pressure. If the joints are carefully made, as described, the practice which obtains in some localities of having a lead

joint on every fourth or fifth pipe to allow for expansion and contraction, need not be followed, as there is little variation of temperature if the pipe is buried under at least 3 feet of cover. If lead joints are used, the leaks will generally be found at these rather than at the cement joints.

The bells of pipes for cement joints should be made at least ½ inch larger than usual in inside diameter to permit of using the hands in manipulating the cement when placed in. The dirt should not be rammed in around the joints until the next day, and the utmost precaution should be used so as not to strike any part of the pipe, as jarring will make new cement joints leak.

Properly made cement joints are absolutely tight, and are so strong that if the pipe and joint are submitted to pressure the pipe will break rather than the cement joint.

**10. Air Test.**—New mains should always be tested in short sections by pumping in air until the pressure is ½ pound or more. The air pressure is supplied by a portable air pump. The pressure gauge should be watched closely, and if it indicates any leak by the gradual lowering of the pressure, the leak or leaks may be found by washing the suspected parts with soapy water. The air pressure will blow soap bubbles over the leaks. All leaks must be closed before the trench is filled. The section of main to be tested must be plugged tightly at each end with temporary plugs.

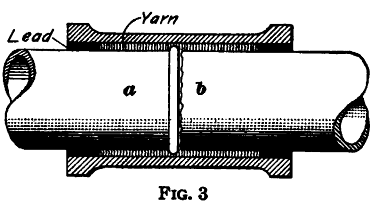

FIG. 3

**11. Sleeves.**—Where two spigot ends have to be connected together, a sleeve is used. This is a short piece of pipe large enough to slip over the pipe on which it is used, leaving space enough for making a lead or cement joint at each end.

Fig. 3 shows an ordinary sleeve in section, covering the spigot end *a* of a pipe and the cut end *b* of another pipe. After the ends *a* and *b* are laid face to face, the sleeve is slipped back and calked in place, care being taken to have the same amount of lap over each pipe.

Where a main has cracked, it may be repaired temporarily by winding canvas, painted with white lead, tightly around the cracked pipe. A permanent repair is made by the use

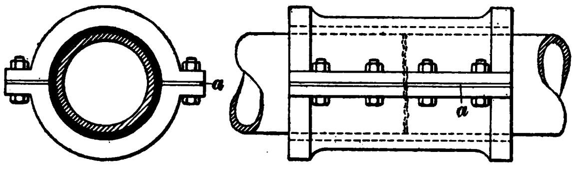


FIG. 4

of a split sleeve, which is made up of two halves that are bolted together, as shown in Fig. 4. A gasket of lead, rubber, or pasteboard is put in at *a* to make the flange joints tight. After the split sleeve has been bolted together around the pipe, lead or cement joints are made at each end in the ordinary manner.

**12. Main Bags.**—Where it is necessary for any reason to cut mains on which the gas pressure must be kept up, main bags, or main stoppers, must be used to hold back the gas when the main is cut. A main bag is shown at *a*, Fig. 5. It is a round rubber bag with a rubber tube leading out of one side. The bags are made of different sizes to fit the different sizes of pipes in use. Thus, a 4-inch bag, when fully inflated, will entirely fill up a 4-inch main.

**13.** A main bag is used as follows: A hole is tapped in the main, as at *b*, Fig. 5, a few feet from the place where the main has to be cut, with the regular tools used for tapping the main for services. The hole must be carefully inspected after it has been tapped, and any slivers of metal around the inside edge removed. The bag, which should be fitted with a small cock *c* at the end of the tube,

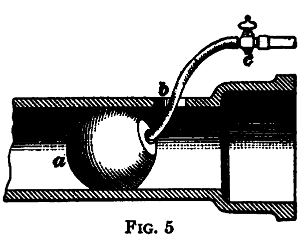


FIG. 5

is then folded up and introduced into the hole, the end opposite the tube being pushed in first. The bag should be pushed well into the main, in the direction from which the gas comes, and

then inflated either by blowing into the tube or by the use of a small pump, such as a bicycle pump. In the latter case, care must be used not to burst the bag. When the bag is fully

TABLE II

SIZE OF TAPPING FOR MAIN BAGS

| Size of Main Inches | Size of Pipe Tap Inches | Size of Main Inches | Size of Pipe Tap Inches |
|---|---|---|---|
| 3 | $\frac{3}{4}$ | 10 | 2 |
| 4 | 1 | 12 | $2\frac{1}{2}$ |
| 6 | $1\frac{1}{4}$ | 14 | 3 |
| 8 | 2 | 16 | 3 |

inflated, the cock in the end of the tube is shut. The main will then be shut off so that it may be cut. When a main is so connected that gas may come from either end, a bag must be put on each side of the part to be cut.

If the main to be bagged is larger than 4 inches, two bags should be put in, one ahead of the other, so that if one bag breaks the other will hold. A good plan is to put in a main stopper first, and then a bag nearer the cut.

**14.** Table II gives the size of the hole to be tapped for main bags in different sizes of mains.

**15. Main Stoppers.**—A diaphragm of canvas or leather mounted on a wire frame, and that may be collapsed and introduced through a hole into the main in a manner similar to that employed with a main bag, is known as a main stopper. Fig. 6 shows such a main stopper in position inside of a pipe. The frame *a* is expanded after the stopper has been pushed inside the pipe, and the diaphragm then shuts off the main.

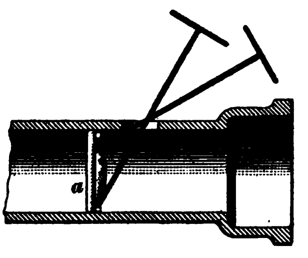


FIG. 6

Main stoppers are not as liable to burst as bags are, but, as a rule, they cannot be made to shut off the gas as completely as bags. It is usually necessary to tap a hole one size larger for a main stopper than is tapped for a main bag.

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### WROUGHT GAS PIPE

**16.** Wrought gas pipe may be used underground if it is thoroughly coated and protected against rust. It corrodes faster than cast-iron pipe under the same conditions, and its durability depends mainly on the care taken to protect it. The smaller sizes of pipe, such as those employed to connect the house pipes with the street mains, should always be galvanized if they run through damp places, and if buried in the ground they should also be protected by an external coating of asphaltum or tar of generous thickness.

When the pipe runs through cinders or coal ashes, the protective coating must be made of extra thickness to resist the corrosive action of the water that filters through the cinders. The pipe should not only be coated with asphaltum in the usual manner, but should also be wrapped with two or more layers of coarse cloth, wound on spirally, and an outer coating of asphaltum applied hot, in sufficient quantity to thoroughly saturate the cloth and cover it.

Galvanizing alone is not a sufficient protection for pipes laid through ashes, or in ground that is permeated with salt or sea-water.

Wrought pipe has an advantage over the cast-iron pipe, inasmuch as the number of joints required in a given distance is much less. Plain black wrought pipe may be employed without hesitation for all the interior piping of a building, except where its appearance would not be desirable. Long lines of screwed wrought pipe of large size should not be laid at a depth of less than 3 feet unless expansion joints are provided at intervals. Otherwise, changes of temperature will cause such strains from contraction and expansion that fittings and couplings may be broken and threads stripped.

### LEAD, TIN, COMPOSITION, AND RUBBER GAS PIPES

**17.** Lead pipe has been used for conveying gas both underground and in buildings, but it is so easily distorted and kinked that iron pipe is now usually preferred. Lead pipe must be protected against corrosion wherever it comes in contact with cement or mortar by a wrapping of building paper and a coating of asphaltum or hot tar.

**18.** Pipes that are made of lead, block tin, or composition have a very smooth interior surface, which favors the flow of gas through them, and they are also capable of being easily bent to suit any position. But, owing to their flexibility, they must be supported on shelving when extended horizontally, to prevent them from sagging and thus forming low places that are liable to accumulate condensation.

The labor of making the necessary connections between soft pipes and the fixtures is greater than with iron pipe, and the first cost of the material is also greater; consequently, the use of soft-metal piping is usually dispensed with as far as practicable.

Soft-metal pipes are liable to be damaged or punctured by nails that may be driven through the woodwork near them, and sometimes holes will be gnawed into them by rats and mice. These little animals seem to like to use their teeth on the soft metal and they will occasionally gnaw a pipe without any other apparent reason.

In the United States of America, neither lead, block tin, nor composition pipe is today used in any service work or for gas-fitting work inside of buildings, except for meter connections, where lead pipe is generally used.

**19.** Pure rubber is not a suitable material for holding gas, because the gas will ooze through it and escape, just as water will ooze through wet paper. When rubber is used for the construction of gas bags and flexible tubing, it must be specially prepared, in order to be gas-tight.

### LAYING OUT GAS MAINS

**20.** In laying out a system of gas mains, a careful estimate should be made as to the probable growth of the locality to be piped, and the mains should then be laid large enough to furnish a proper supply for a long period in the future. The most efficient and best, as well as the cheapest, way to pipe a locality is to lay a large main through it in the direction of its greatest length and to lay smaller lateral mains from the large main on the streets at right angles to it. The streets that parallel the one in which the large main is laid may be supplied by still smaller mains connecting the lateral mains. Then, in case the system is to be extended lengthwise, it is only necessary to extend the large main and put on more lateral mains, while if the locality builds up to the right or left of the large main another large main can be run parallel to the first and at some distance from it and the ends of the lateral mains connected into it.

This system is better than the usual one of beginning with a large main and reducing it in size as the various branches are taken off, thus forming a main system similar to the branches of a tree. In the first place, it is the cheaper in the end, as it obviates the necessity of taking up mains that have become too small and laying larger pipe, and in the second place, it allows a more even pressure all over the district supplied and obviates the necessity of carrying a high pressure near the works.

Where the gas supply in a street must be increased, the main that is too small should be taken up and a larger one laid. The small main may then be relaid in some suitable locality. It costs but little more to dig up the old main and lay the new one in the same ditch than it does to dig a new ditch for the new main.

Parallel mains should not be allowed in the same street except in cases where, on account of paving or other reasons, the mains must be laid under the sidewalks. It costs much less to lay one large main of a given capacity than it does to lay two small mains of the same capacity; and, as in the

latter case the number of joints will be doubled, the leakage will be greater for the same amount of gas supplied and the cost of repairs and maintenance will be nearly doubled.

Where mains must be laid on both sides of a street, the best practice is to lay a large main on one side and a small one on the other, connecting the two at frequent intervals, since it is cheaper to lay a large main and a small one of a given capacity than it is to lay two mains of equal size of the same capacity. The small main in the first case, being reinforced at frequent intervals, suffers but little loss in carrying capacity by reason of friction and can therefore be made quite small in proportion to the volume of gas that it is to supply.

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### GAS-PIPE FITTINGS

**21.** The fittings employed in gas piping in buildings are generally similar to those made for steam and water, except that some are provided with lugs or flanges by which they can be firmly fastened to the walls and ceilings.

They should be made of malleable iron for all sizes up to 2 inches diameter; for larger sizes, cast iron may be used. Galvanized fittings are to be preferred to plain iron fittings, because the coating of zinc will usually penetrate into any small pinhole that may exist, and will effectually seal it against leakage.

Defective fittings should not be employed in any case, and when one is discovered in use it should be promptly removed, if possible, and be replaced with a perfect one. The practice of patching holes or defects in fittings or pipes with wax cement is dangerous and should be condemned. The cost of replacing defective fittings with sound ones is so small in proportion to the damage that may be done by a leak, such as vitiating the air or suffocating some person, or causing an explosion or fire, that the gas-fitter is not justified in risking anything on the durability and permanency of a cement patch. Such patches are especially unsafe if they are in the vicinity of steam or hot-water pipes or hot-air flues, or are near a hot chimney, as the heat will soften the wax.

**22.** A number of fittings especially designed for gas piping are shown in Fig. 7. They are made of malleable iron and are known in the trade by the following names: *a*, quarter elbow; *b*, tee; *c*, street elbow; *d*, cross; *e*, elbow with side outlet; *f*, right and left coupling; *g*, reducing coupling; *h*, cap; *i*, male and female extension piece; *j*, plug; *k*, waste nut;

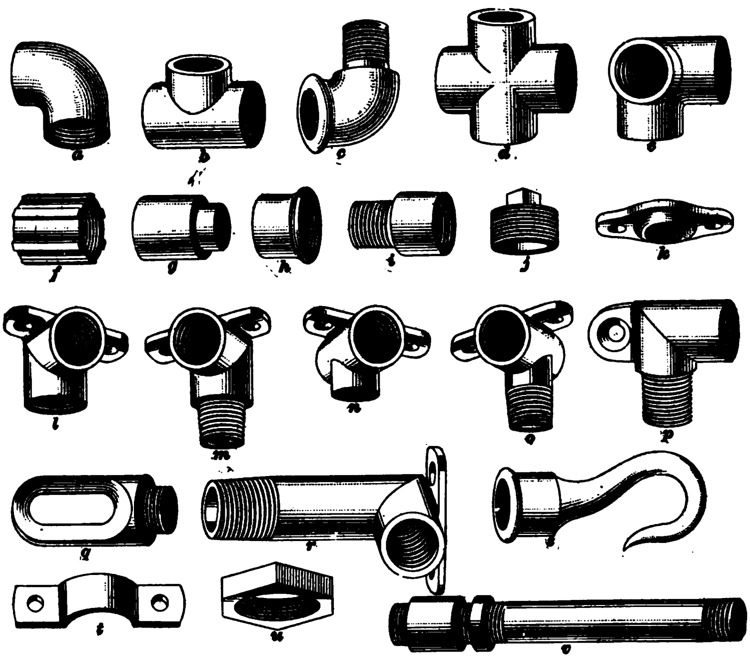

Fig. 7

*l*, drop elbow, with female thread; *m*, drop elbow, with male thread; *n*, drop tee, with female thread; *o*, drop tee, with male thread; *p*, drop elbow, with male thread, left flange; *q*, male chandelier loop; *r*, drop elbow with long outlet piece; *s*, chandelier hook, female; *t*, pipe strap, tinned; *u*, locknut; *v*, long screw. The flanged fittings can be had either right or left, and also with male or female threads.

# GAS DISTRIBUTION

## FLOW OF GAS THROUGH PIPES

### LAWS GOVERNING FLOW OF GAS

**23.** The flow of gas is governed by the same laws that govern the flow of other fluids. The rate of flow depends on: (1) the area of the pipe; (2) the length of the pipe; (3) the pressure of the gas; (4) the density of the gas; (5) the number and kind of fittings in the length of the pipe.

The volume delivered in a given time by a pipe of given area, the pressure and density of the gas remaining the same, will be inversely as the square root of the length of the pipe.

If the length, area, and density remain the same, the volume delivered will be directly as the square root of the pressure.

The pressure, length, and area remaining the same, the volume delivered will be inversely as the square root of the density.

**24.** If the rate of flow through any certain length of pipe is known, the volume that will be delivered by a longer or shorter pipe of the same diameter, in the same time, the pressure and density of gas remaining the same, may be found by the following rule:

**Rule.**—*Multiply the volume delivered by the pipe of given length by the square root of that length, and divide the product by the square root of the proposed length. The quotient will be the delivery at the proposed length.*

Example.—A certain pipe 50 feet long delivers 100 cubic feet of gas per hour; how much will it deliver if it be made 150 feet long?

Solution.—According to the rule,

$$\text{delivery} = \frac{100 \times \sqrt{50}}{\sqrt{150}} = 57.71 \text{ cu ft.} \quad \text{Ans.}$$

**25.** The volume that will be delivered under different pressures may be computed by the following rule:

**Rule.**—*Multiply the volume delivered at the given pressure by the square root of the proposed pressure, and divide the product by the square root of the given pressure. The quotient will be the delivery at the proposed pressure.*

The pressure to be considered in each case is the excess of the pressure of the gas when it enters the pipe, above the pressure existing in the chamber into which it discharges; or, in other words, it is the difference in pressures at the inlet and discharge end of the pipe.

EXAMPLE.—A certain pipe discharges 100 cubic feet of gas per hour from a reservoir having an internal pressure of 1.6 inches of water, into the atmosphere; what volume will be discharged per hour if the pressure is increased to 5 inches of water?

SOLUTION.—According to the rule,

$$\text{delivery} = \frac{100 \times \sqrt{5}}{\sqrt{1.6}} = 176.7 \text{ cu. ft.} \quad \text{Ans.}$$

**26.** The pressure that must be put on a main to discharge a given volume, when the delivery under another pressure is known, may be computed by the following rule:

**Rule.**—*Square the desired volume and multiply it by the given pressure. Divide this product by the square of the known volume. The quotient will be the desired pressure.*

EXAMPLE.—A certain pipe delivers 80 cubic feet of gas per hour, from a main having an internal pressure of 2.4 inches of water; what pressure must be put on the main to cause the pipe to deliver 150 cubic feet per hour?

SOLUTION.—According to the rule,

$$\text{pressure} = \frac{150^2 \times 2.4}{80^2} = 8.44 \text{ in.} \quad \text{Ans.}$$

**27.** The effect of variations in the density of the gas on its flow may be computed by the rule in Art. **24**, by merely substituting the word *density* for the word *length*.

The foregoing rules apply only to the theoretical flow of gas under perfect conditions. In practice, perfect conditions

are never attained; consequently, the actual flow of gas in pipes is less in volume than that computed by the rules given. The deficiency varies according to the amount of friction and other resistances within the pipe.

**28.** The actual volume of gas discharged from a pipe may be calculated quite closely by the following empirical rule due to Mr. King:

**Rule.**—*Multiply the diameter of the pipe in inches four times by itself, and the final product by the pressure in inches of water. Divide this product by the product of the specific gravity of the gas (air being taken as 1) and the length of the pipe in yards. Extract the square root of the quotient and multiply the square root by 1,350. The product will be the number of cubic feet of gas discharged per hour.*

EXAMPLE.—How much gas per hour can be discharged by a pipe 1,760 yards long and 10 inches diameter, the pressure being 3 inches and the gas having a specific gravity of .4?

SOLUTION.—According to the rule,

$$\text{delivery} = \sqrt{\frac{10\times10\times10\times10\times10\times3}{.4\times1,760}}\times1,350 = 27,864 \text{ cu. ft.} \quad \text{Ans.}$$

### GAS PRESSURE AND ITS MEASUREMENT

**29. Influence of Height on Pressure.**—If the specific gravity of a gas is less than that of air at the same temperature, the pressure will always be greater at the top of the pipe or chamber that contains the gas. If the gas is heavier than air, the greater pressure will be at the bottom of the chamber that contains it.

The upward pressure of gas having a less density than air is caused by the deficiency in its weight and its consequent inability to balance the pressure of the atmosphere.

For illustration, a column of gas may be considered, which is 1 foot square and 100 feet high, having a density of .5, or one-half that of air, its temperature being the same as that of the atmosphere, say 60°. Air at 60° weighs .0764 pound per cubic foot, and a column containing 100 cubic feet weighs .0764

$\times 100 = 7.64$ pounds. The gas having a density of .5 will weigh only half as much, or 3.82 pounds, and is, therefore, unable to balance an equal volume of air. Consequently, it is pressed upwards with a force of $7.64 - 3.82 = 3.82$ pounds against the top of the chamber that contains it. Whatever the actual pressure of the gas may be at the bottom of the column, it will, in this case, be increased at the top to the extent of 3.82 pounds per square foot.

**30.** The increase of pressure in each foot of rise in pipes with gas of various densities, is shown in Table III.

EXAMPLE.—The pressure in the basement, at the meter, is 1.2 inches of water; what will be the pressure at the sixth story, 70 feet above, the density of the gas being .4?

SOLUTION.—By Table III, the increase per foot of rise is .0088 in.; hence, for 70 ft. it is $.0088 \times 70 = .616$ in. of water. Then, pressure at sixth story is $1.2 + .616 = 1.816$ in. Ans.

**31. Measurement of Gas Pressure.**—Since the pressures dealt with in gas supply and distribution are quite

TABLE III

INCREASE IN GAS PRESSURE PER FOOT OF RISE

| Density of gas | 1 | .9 | .8 | .7 | .6 | .5 | .4 | .3 |
|---|---|---|---|---|---|---|---|---|
| Increase in pressure (inches of water) | 0 | .00147 | .00293 | .0044 | .0058 | .0073 | .0088 | .0102 |

small, it is the custom to use a unit of measurement of the pressure smaller than the pound per square inch used for steam work. The universally adopted unit is the pressure per square inch exerted at its base by a column of water 1 inch high, which is .0361 pound. For the sake of brevity and convenience, the pressure is not reduced to pounds, but is expressed by simply stating the height of the water column in inches that the pressure will balance. Thus, if there is a pressure in a gas main sufficient to balance a column of water $4\frac{1}{2}$ inches high, the pressure is said to equal, or to be, $4\frac{1}{2}$ inches of water.

The pressure of gas is measured by the same instruments used for air and other fluids. The construction of the instruments, however, is varied somewhat for convenience in handling.

FIG. 8

**32.** The most common form of gas-pressure gauge is shown in Fig. 8. It is known by different names, being respectively called a *water gauge*, *siphon gauge*, or **U** *gauge*. The tube $a$ is made of metal and is provided with a socket $d$ that will screw on any ordinary gas fixture in the place of a burner. The tubes $b$ and $c$ are made of glass and are filled with water up to the zero of the scale. The scale is graduated in inches and convenient fractions of an inch. The tube $c$ is open to the air at the top. When pressure is admitted to the tube $a$, the water will sink in the tube $b$ and will rise in $c$. The difference in the height of the water in the two tubes, measured in inches, is the measure of the pressure exerted in *inches of water*. The depression below zero in $b$ should be added to the rise above zero in $c$. The fall in one tube will not exactly equal the rise in the other, unless the tubes are of exactly equal bore.

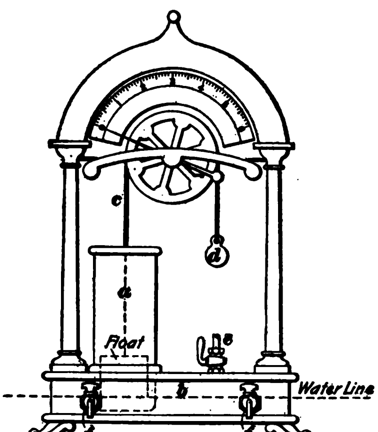

FIG. 9

Water gauges are sometimes made with scales that are graduated to one-half of actual sizes, so that only the rise in one tube need be noted. An instrument that is graduated in that way must be held exactly plumb, and the water must stand exactly at zero at the start; otherwise, it will be found that the rise and fall will not be equal, and must be averaged to get the true pressure.

**33.** The **Arch, or King, gauge,** shown in Fig. 9, consists of a cylinder *a* that runs down through the top of the tank *b* and dips its open bottom into the water with which the tank is partly filled, as shown by the dotted lines. The tank is also open at the top and contains a float, shown by dotted lines, which rests on the water inside the cylinder. This float is connected by the cord *c*, which runs over a wheel, to the weight *d*. When gas under pressure is admitted through *e* to the space above the water in the tank *b* the pressure forces the water in the tank down and the water level in the cylinder *a* is correspondingly raised. The float is raised along with the water level in the cylinder. This slacks the cord *c*, which allows the weight *d* to pull the wheel toward it. The pointer, which is on the same axis as the wheel, turns toward the right at the same time and indicates in inches of water the amount of pressure applied. The petcocks *f* are used to drain off water from the tank until the pointer is exactly at the zero mark, when the pressure in the tank is equal to that of the atmosphere.

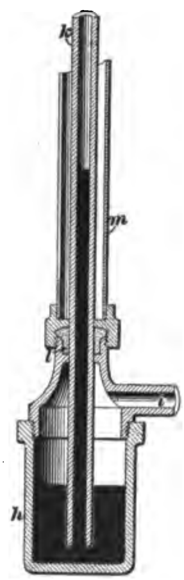

FIG. 10

The amount of movement of the pointer depends on the size of the wheel. The proportion of the apparatus may therefore be so arranged as to give any degree of sensitiveness required, and variations of pressure that could not be observed on the water gauge shown in Fig. 8 may be satisfactorily noted.

**34.** It is readily seen that if comparatively heavy pressures are to be measured, the water gauge will become so large as to prove inconvenient as a portable instrument. By substituting a heavier liquid for the water, the bulk will naturally be greatly reduced. The liquid generally used is mercury, which is 13.6 times heavier than water, and the gauge is then spoken of as a **mercurial gauge.**

Mercurial gauges for gas-fitters' use are commonly made as shown in Fig. 10, and are known as **cup gauges.** They

are always graduated to give a reading in *inches of water*, and *not* in inches of mercury.

In Fig. 10 the mercury is contained in an iron cup *h*, and the air or gas under pressure enters through the tube *i*. The glass tube *k* is packed or cemented air-tight at *l*, and is protected by a tubular brass casing *m*. When the mercury rises in the glass tube, it sinks in the cup, but to a much smaller extent. The graduations on the brass casing indicate the difference of level that exists between the mercury in the tube when standing at that height, and the actual surface of the mercury in the cup.

To indicate correctly, this gauge must contain exactly a certain quantity of mercury, no more or less. It can be tested, or *calibrated*, at any time by comparing it with the gauge shown in Fig. 8, adding or taking out mercury from the cup until they agree. If they agree at some points and not at others, then the scale is defective and should be regraduated.

When in use, the glass tube must always be open to the air at the top.

**35.** Pressures that have been measured in inches of water or mercury may be changed to pounds per square inch or square foot by multiplying the reading by the following figures: 1 inch of water at 62° = 5.2 pounds per square foot; 1 inch of water at 62° = .0361 pound per square inch; 1 inch of mercury at 62° = .4917 pound per square inch.

Pressures per square inch or square foot may be converted into inches or feet of water, or inches of mercury, by multiplying the pressures by the following figures: 1 pound per square foot = .1923 inch of water at 62°; 1 pound per square inch = 27.7 inches of water at 62°; 1 pound per square inch = 2.042 inches of mercury at 62°; 1 inch of mercury column = 13.6 inches of water column.

### MEASURING VELOCITY OF FLOW OF GAS

**36.** The velocity of gas flowing through a pipe may be measured by means of **Pitot's tube,** which is shown in Fig. 11. It consists of two tubes *a* and *b*, which are secured in a suitable plug *c*. The lower end of *a* is straight, but the end of *b* is curved to face the current, as shown. The upper ends of the tubes are connected to a water gauge *d*. The pressure that affects the gauge is due to the momentum of the gas that strikes the open end of the tube *b*. The velocity that corresponds to any certain indication of the water gauge may be found by referring to the tables that are furnished by the maker of the instrument.

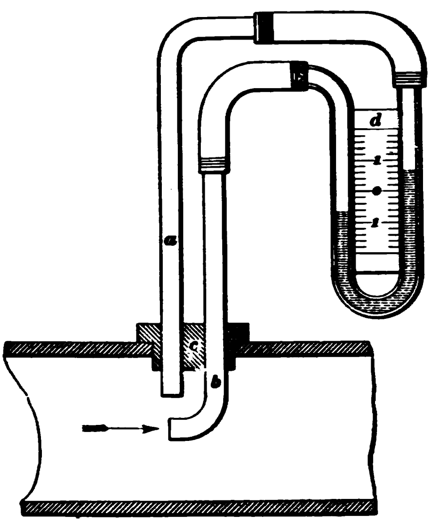

FIG. 11

The volume of gas passing through a pipe in a given time is computed by multiplying the velocity, as found by Pitot's tube, by the area of the pipe.

**37.** The actual quantity of the gas, or the **standard volume,** is computed by correcting the volume for temperature and pressure, reducing it to a volume at standard temperature of 32° and standard pressure of 1 inch of water. The correction for temperature and pressure is made by the following rule:

**Rule.**—*Multiply the volume by 1.206 and by the sum of the pressure in inches of water and 407. Divide the product by the sum of the temperature, in degrees Fahrenheit, and 460. The quotient will be standard volume.*

EXAMPLE.—A pipe passes 2,252 cu. ft. of gas per hour at 94 degrees under a pressure of 8 inches of water. What is the standard volume?

SOLUTION.—Applying the rule just given, we have

$$\text{standard volume} = \frac{2,252 \times 1.206 \times (8+407)}{94+460} = 2,034.5 \text{ cu. ft.} \quad \text{Ans.}$$

In dealing with gas it is necessary to keep in mind a clear distinction between the *apparent volume* of the gas and the *actual quantity*. The former is the volume as measured at the actual temperature and pressure, while the latter is the volume of the same gas at standard temperature and pressure.

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## MEASURING VOLUME OF GAS

**38.** For ordinary purposes, the volume of gas passing through a pipe is measured by an apparatus called a **gas meter.** A gas meter measures the *volume* only. It gives no indication as to the pressure under which gas is being metered; but as most meters are adjusted at a pressure of less than 2 inches of water column, and as that pressure is usually the minimum used in the street mains, the error possible from variations in pressure is very slight. For example, if a meter registers 1,000 cubic feet of gas at the pressure for which it is adjusted, say 2 inches of water, it will actually pass 1,004.9 cubic feet at 5 inches pressure, and yet register but 1,000 cubic feet. It is thus seen that the error is less than one-half of 1 per cent. for an increase in pressure of 3 inches, and in favor of the customer, and not of the gas company, as is commonly assumed.

The maximum pressure at any meter is seldom more than 5 inches; the average maximum pressure of the total number of meters in use on any system of mains is probably not more than 3 inches. Wherever gas is piped under very high pressure, as in the case of natural gas, or where illuminating gas is pumped from one district to another, a governor or reducing valve is always placed on the service, so that the pressure is reduced before the gas reaches the meter.

**39. Construction of Gas Meters.**—Meters for measuring the volume of gas have been constructed in many ways. The kinds that are most in use at the present time are shown in Figs. 12, 13, and 14.

The **wet meter** is shown in Fig. 12. The gas enters through a pipe *a*, which opens just above the surface of the water. The measuring is done by means of a revolving cylinder that is divided by partitions into four chambers *b*, *c*, *d*, and *e*. The inner ends of the partitions are curved so that they dip under the water and prevent the incoming gas from entering any other chamber than the one that is rising out of the water. In the figure, gas is beginning to fill the chamber *b*, and it is discharging freely from the chamber *d* into the outer casing to which the discharge pipe is attached. The outlet of the chamber *c* is still under water, and no gas can escape from it until the cylinder turns over a little farther. The filling and emptying of the chambers continue as long as any gas is passing through the meter.

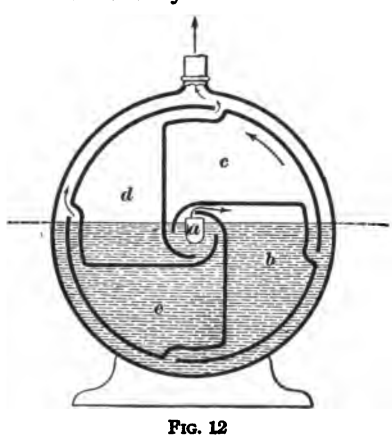


FIG. 12

The capacity of each chamber depends on the level of the water within it; consequently, the water must be kept exactly at a proper level at all times to enable the meter to measure accurately. The axis of the cylinder must be exactly horizontal; otherwise, the capacity of the chambers will be increased and the meter will indicate less than the true volume passing through. Also, the water will evaporate and pass off as vapor along with the gas, and, unless replenished, the meter will become more and more inaccurate, until finally the gas will pass through without registering at all. Many dishonest persons have taken advantage of the fact that by tipping the meter so that one end of the cylinder is considerably higher than the other, the water may be made to uncover the inlet and outlet openings of a chamber at the same time, thus permitting the gas to pass through without turning the cylinder or registering.

The best forms of wet meters are provided with a float attachment that automatically closes the gas inlet when the

water-line is too high or too low, thus obtaining a reasonably uniform measuring capacity in the meter, and preventing a passage of gas without a corresponding movement of the drum.

The wet meter is sufficiently accurate if kept in good order, but owing to the defects mentioned, it is now but little used for measuring the amount of gas supplied to consumers. It is still employed at gasworks, in preference to all others, to measure the total amount of gas produced. For this purpose it is made very large and is provided with glass gauges by which the level of the water may be observed and accurately controlled. It is then called a **station meter.**

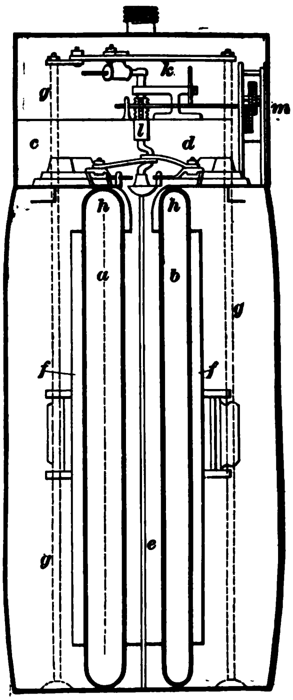
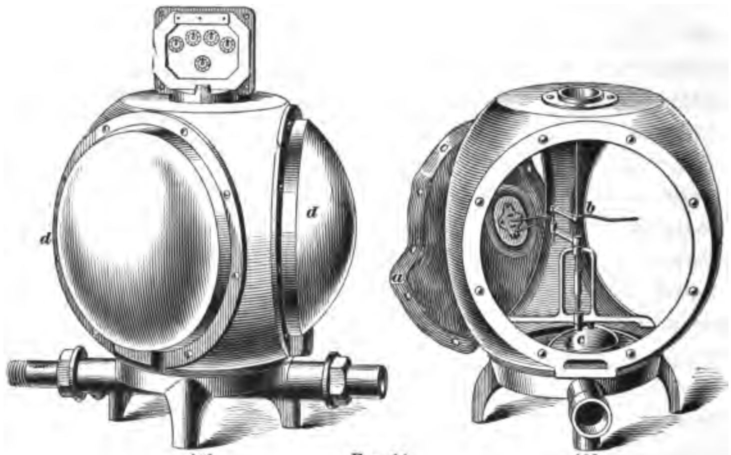


FIG. 13

**40.** An ordinary design of **dry meter** is shown in Fig. 13. The measuring is done by means of two bellows *a* and *b*, which are alternately inflated and emptied. The meter case is divided into three chambers, the upper one containing the valves *c* and *d* and the registering mechanism. The body of the case is divided by a partition *e* into two equal chambers, each of which contains one of the bellows. Each bellows consists of a large circular plate *f* attached to and supported by the vertical rock shaft *g*, and a flexible ring or diaphragm *h*, having one edge secured to the plate *f* and the other to the middle partition *e*. The rock shafts *g* are connected at the top by arms and links to a central crank *k*. The throw or stroke of the plates *f* is thus limited to an exact distance and the relative movements of the two bellows are so timed that the movement of gas through them is steady and nearly uniform. The interior and exterior spaces of the two bellows constitute four measuring chambers, and the gas is admitted

to and released from them in rotation, by the movement of the slide valves *c* and *d*. These valves are moved by means of links connected to the crank on the lower end of the central shaft *l*. The amount of gas passed through by each bellows at one revolution of the shaft nearly equals the area of the circle filled by the leather ring *h* multiplied by the actual distance through which the plate *f* is moved, or twice its stroke.

The capacity of the meter is regulated by adjusting the radius of the crank *k*, and thus changing the length of the stroke of the bellows. The rotations of the shaft are recorded




(a) FIG. 14 (b)

by the registering mechanism at *m* and the volume passed through is indicated in cubic feet.

The rings or diaphragms *h* are usually made of fine leather. After long service these rings are liable to become hard and stiff, and to crack. To keep them in good serviceable condition, they must be oiled at intervals. When the meter is used for gas that has not been properly purified, the leather rings are liable to become coated with tarry matter and thus be spoiled.

**41.** Dry meters are also made with three diaphragms, which are sometimes made square. An external view of a dry meter designed especially for natural gas and high pressures is shown in Fig. 14 (*a*), and an inside view of the working

part in Fig. 14 (*b*), in which view two of the diaphragms and the cover-plates have been removed.

Three diaphragms, as *a*, are employed, each one being connected by a link to the central crank *b*. The diaphragms are single-acting, that is, they displace gas only when they move outwards into the chambers enclosed by the covers *d*. The central or main chamber is filled with gas at full pressure at all times. The gas is admitted and released from the measuring chambers behind the diaphragms by means of a hollow circular slide valve *c* that is attached to the crank on the lower end of the central shaft. When gas is admitted to a measuring chamber, the diaphragm is balanced, having an equal pressure on each side, and it moves inwards in obedience to the crank, without resistance, thus filling the chamber behind it. But when the valve cuts off the fresh gas and opens a duct into the delivery pipe, the pressure in the central chamber exceeds that in the delivery pipe and the diaphragm is driven outwards, expelling the gas from the measuring chamber. Thus the measuring chambers are filled and emptied in regular rotation. The shape of the meter being spherical, it can endure high pressures without distortion or any impairment of its accuracy.

**42.** All gas meters require a certain small amount of power to operate them; consequently, the pressure of the gas will be slightly reduced in passing through the meter. In the ordinary size used in dwellings, the reduction of pressure usually amounts to about .2 inch of water, sometimes more. When gas is supplied at very low pressure, it becomes difficult to use a meter, because the resistance that it offers diminishes the pressure at the burners to such an extent that the gas will not burn well.

Thus, if gas is furnished at a pressure of .5 inch and the resistance of the meter is .2, then the gas passing to the burners will have a pressure of only .3 inch, and will burn in such a languid way that it will be very unsatisfactory.

**43. Size of Gas Meter.**—The numbers usually affixed to gas meters indicate the number of gas burners consuming

5 cubic feet each per hour, which the meter will supply with ease and certainty. In practice, the number of burners may be increased to double the number on the meter.

Gas meters should not be exposed to a lower temperature than 40°, nor a higher temperature than 100°, since the oiled leather in the diaphragms will be injuriously affected thereby.

Some knowledge of the internal condition of a meter can be ascertained by noting the difference in pressure in the supply and delivery pipes. A water gauge should be attached to each pipe as close to the meter as practicable. If the gauges show a difference greater than .2 inch in pressure, the

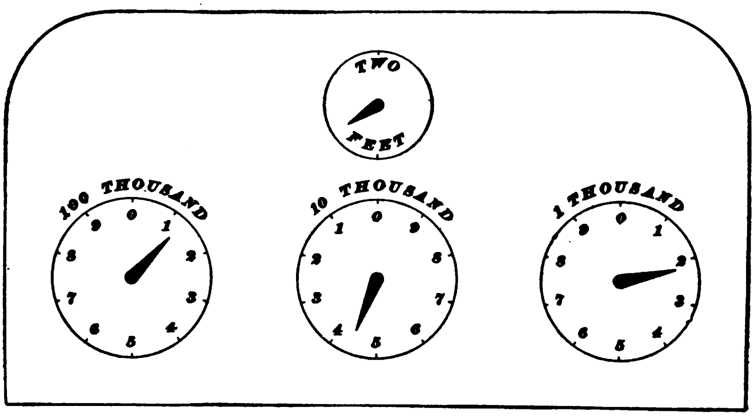



FIG. 15

meter should be removed and examined. The accumulation of water in the meter may cause the trouble, in which case it must be emptied. Or, the meter may be out of order, in which case it must be repaired.

**44. Reading Gas Meters.**—Fig. 15 is a diagram of a *meter dial* of the ordinary type. When the pointers all indicate the zero mark on their respective dials, the meter is said to be at zero. If the meter is at zero and a certain volume of gas is allowed to pass through it, the number of cubic feet of gas passing through the meter will be indicated on the dials. If the meter is not at zero, however, the number of cubic feet of gas that has actually passed through during the

time specified is equal to the difference between the number indicated on the dials before the gas was allowed to flow through the meter and that indicated when the gas has flowed through.

The top dial is marked *two feet*, which means that when 2 cubic feet of gas have passed through the meter the pointer of this dial will have made one revolution.

When 1,000 cubic feet of gas have passed through the meter, the pointer of the dial to the right, which is marked *1 thousand*, will have made one complete revolution, and the pointer of the middle, or *10 thousand*, dial will have moved from *0* to *1*. When the pointer to the right has made another revolution, the pointer of the middle dial will have moved from *1* to *2*, which means that two complete revolutions of the pointer to the right have been made. When the middle pointer has made one complete revolution, the pointer to the left will have moved from *0* to *1* on the *100 thousand* dial, which means that $\frac{1}{10}$ of 100,000, or 10,000 cubic feet, have passed through the meter.

To read a meter dial of this description, first write down the figure that the pointer has just passed on each dial; then annex two ciphers to the right; the number so obtained will be the amount of gas in cubic feet that the meter has measured. The dials should be read from left to right.

Thus, the pointers on the diagram indicate that 14,200 cubic feet of gas have passed through the meter. When the pointer to the left has made one complete revolution, the process of indicating is repeated. The pointers all move from the smaller to the larger figures, just like the hands of a clock.

Gas meters are not read in practice to a smaller amount than 100 cubic feet. By watching the top dial it can be seen, at a very small expenditure of gas, whether the meter is working, by opening some outlet on the house side of the meter.

**45. Testing Gas Meters.**—Meters are tested by means of a *meter prover*. This is principally composed of a metal cylinder or gas holder *a*, Fig. 16, usually capable of holding

either 5 or 10 cubic feet of gas. The holder is open at the bottom, and is placed inside a slightly larger cylinder or tank *b*, which is open at the top and nearly filled with water. There is a pipe in the center of the water tank, the upper end of which pipe terminates above the water level, the lower end connecting to the pipe *c*. This pipe gives an inlet and

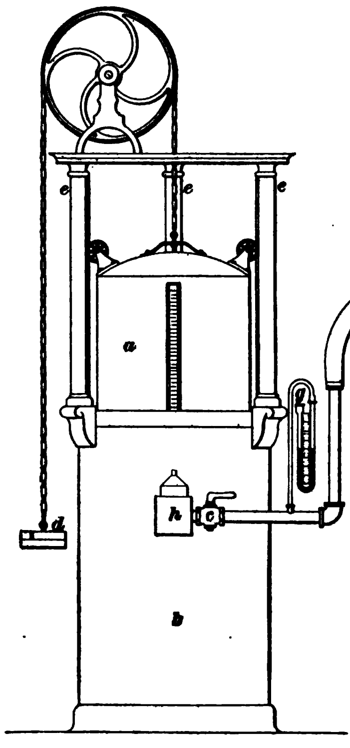



Fig. 16

outlet to the space between the top of the water and the under side of the top of the gas holder. The holder is free to rise up out of the water, and its weight is partly counterbalanced by a cord or chain that runs over a wheel set above the tank and that has a weight or counterbalance *d* on the other end. The counterbalance is usually such that a pressure of more than 1½ inches of water column under the tank

will raise it. The tank is guided while it is raised by guide wheels that are set at three points on its circumference and run against the guide posts *e*. A scale is attached to the outside of the holder and shows in subdivisions of a cubic foot how much air or gas is required to fill the space above the water at any height the tank might be in the water. As the results are the same with either air or gas, air is generally used in the prover for the sake of convenience. The pipe *c* that comes from the inside of the prover is provided with a valve for the admission of air and with another valve leading to a connection, usually on the end of a rubber hose, for the attachment of meters. A **U** gauge is always provided near the outlet of this valve, as shown at *g*.

**46.** The prover is operated as follows: A meter is connected to the coupling end *f* of the rubber hose and the cock *c* is closed. The air valve at *h* is then opened and the tank is raised a little by pulling down on the counterbalance. Air thereupon enters the inside of the tank through the air valve, which is closed before the counterbalance is released. The outlet of the meter is closed either by the hand or by a suitable cap, and the cock admitting air to the meter is opened. The gauge will at once show a pressure of 1½ inches. The cock *c* is then closed and the pressure gauge observed. If the gauge remains at 1½-inch pressure, the test may be continued, but if the pressure falls, there is a leak somewhere in the connections, which must be found and stopped and the above leak test repeated before anything else is done.

All connections being gas-tight, the cap is removed from the meter outlet, the cock *c* is opened, and air is allowed to pass through the meter until the 2-foot hand just points toward one of the side marks on the 2-foot dial. A meter test should never be started from either the bottom or top mark. When the hand reaches the side mark, the cock *c* is closed. The air valve is then opened and the prover tank is raised until the zero mark on the scale is 2 or 3 inches above a pointer that is set on the water tank *b* just above the waterline. The air valve is then closed and the prover tank released.

The prover tank will come to rest, supported by the air that has been drawn inside it, and the zero mark will be a little above the pointer. The air valve is then opened a little and air is allowed to escape until the zero mark is just level with the pointer. The air valve is now closed and the meter cock *c* is opened. The air will pass out through the meter and the small hand on the meter dial will at once begin to move. The small hand should be carefully watched, and when it has made one complete revolution and returned to the side mark from which it started, the meter cock *c* should be quickly closed.

The pointer will be found to point exactly at the 2-foot mark on the prover tank scale if the meter is exactly right. If the pointer indicates a position on the scale that is $\frac{1}{100}$ of 2 feet below the 2-foot mark, 1 per cent. more air has gone through the meter than the meter has registered, and the meter is accordingly 1 per cent. slow. If the pointer indicates a corresponding position above the 2-foot mark, the meter has registered 2 feet when only $\frac{99}{100}$ of 2 feet of air has left the prover, and the meter is 1 per cent. fast. The subdivisions on the prover scale are usually arranged so that the direct reading shows the percentage fast or slow, each subdivision being equal to 1 per cent.; hence, no calculating is necessary. On large meters the small hand may register 5 or even 10 cubic feet at one revolution, and a proper subdivision for directly reading a 5-foot and 10-foot test will usually be found on the prover scale.

**47.** The test described in the preceding article is called the **open test,** because the meter has been open, or rather blowing with a full opening, to the atmosphere. After the open test has been made, the same process should be repeated with a cap, in which a small hole has been drilled, placed on the outlet of the meter. The hole in this cap should be of such a size that the number of feet of gas passed per hour will be equal to six times the number of burners the meter is rated for. Thus, a 3-light meter cap has a hole large enough to pass about 18 cubic feet per hour. This test is for the

purpose of placing the meter more nearly under the conditions of average use; it is called the **slow test**. The slow and open tests should agree within 2 per cent.; if they do not, there is something wrong with the meter and it should be opened and repaired. The slow test should be taken as the correct test of the meter. Suitable caps are always provided by the manufacturers of meter provers. In proving meters, the temperature of the air in the room and of the water in the prover tank must be as nearly the same as possible, and two thermometers should be provided for ascertaining the temperature.

As each difference of 5° will make a difference of about 1 per cent. between the registration of the meter and that of the prover, the necessity of an even temperature may be readily seen. The water in the prover tank may be readily brought to the temperature of the air in the room by adding cold water if it is too hot and hot water if it is too cold. Meters, for the reason above stated, should be allowed to remain in the proving room for some time before being tested, and if they have been brought in from outdoors on very cold or very hot days, several hours should be allowed to elapse before proving them. If the meter, the air in the room, and the water in the prover are all at the same temperature, there is no practical difference what that temperature may be. In many shops it is considered better to allow the 2-foot hand on the meter to make two revolutions instead of one during a test. In this case each division on the prover scale that would be 1 per cent. in a single revolution will be ½ per cent.

**48.** When very large meters are to be proved, the test dial frequently requires more air for one complete revolution than the capacity of the prover will allow. In this case the prover must be filled twice or more. Suppose that a meter, the test dial of which registers 20 cubic feet, is to be tested on a 10-foot prover. The prover is set at zero and the test hand at one of the side marks, and exactly 10 cubic feet by the prover scale is allowed to pass to the meter. No attention being given to the position of the dial hand when it stops,

the prover is refilled with air, brought to zero again, and once more allowed to descend. This time the hand on the meter is watched, and when it gets around to the point from which it started, the meter cock is again shut and the reading on the scale taken. In this case it will be readily seen that each difference of $\frac{2}{10}$ foot above or below the 10-foot mark amounts to 1 per cent. slow or fast, as the case may be.

**49. Accuracy of Gas Meters.**—Meters that are within 2 per cent. of being correct are regarded as right, whether fast or slow, this being the range generally allowed by law in places where laws governing the registration of meters exist. Notwithstanding the prejudice of the public to the contrary, the tendency of all meters is to run slow rather than fast. Indeed, every dry meter, if left in use long enough, will run slow, as sooner or later the leather diaphragms begin to rot and small holes appear that allow gas to pass without registering, and these holes grow larger and larger until the meter ceases to register any of the gas that passes through it. For this reason it is good practice for gas companies to make a routine test of some of the meters in use in any district each year, so that every meter will be tested once in 3 or 4 years.

The life of the diaphragms may be very much prolonged if the meters are opened up and the diaphragms oiled with neatsfoot oil.

# GAS SUPPLY AND DISTRIBUTION

(PART 2)

## GAS DISTRIBUTION

### REGULATING FLOW OF GAS

#### PRELIMINARY REMARKS

**1.** The pressure in gas mains and services is mainly artificial, being created by the weight of the holders in which the gas is stored at the works. This pressure is regulated by a governor at the works to a day pressure of about 2 inches, as the ranges and other fuel appliances in use work best at about this pressure. At night, when there is a very heavy consumption of gas, it is frequently necessary to increase the pressure at the works to 4 or 5 inches, in order to deliver gas with sufficient pressure to the consumers at the far ends of the mains. On this account, the consumers near the works have more pressure than is necessary, which is very undesirable. Here, it may be mentioned that any increase in gas pressure means an increase in the leakage of gas mains, and for this reason, contrary to the usual belief, gas companies rarely carry more than just enough pressure to supply the more distant points of their main system properly.

A burner that is designed to consume, say, 5 cubic feet of gas per hour, will work most efficiently when it is supplied with just that quantity—neither more nor less. If only 4 cubic feet are supplied, the flame will be dull and smoky,

and the amount of light will be considerably less than that normally produced by a 4-foot burner using the same gas. If 6 cubic feet be forced through the burner, the flame will flare and jump and the light given off will be less than that produced by the same amount of gas going through a 6-foot burner.

If the volume of gas passed through a burner considerably exceeds the amount it was designed to burn, some of the excess will pass through without being burned and will vitiate the air of the room in which it is used.

**2.** The pressure that should be given to the gas at the burners, in order to secure the best results, varies greatly in different forms of apparatus. The following are the pressures generally used: Argand burners, .2 inch of water; common batswing burners, .5 inch of water; Welsbach incandescent burners, 1 inch or more; Wenham and Lebrun lamps, .5 to 1 inch or more; atmospheric burners, 1 inch or more.

For the sake of economy, it is important that both the volume and pressure at the burners should be closely regulated. The amount of gas wasted by overpressure is much greater than is generally known. A good new lava-tip burner consuming 5 cubic feet per hour at .5 inch pressure will consume about .5 cubic foot or more for each increase of .1 inch in the pressure. Thus, an overpressure of .1 inch will increase the gas bill about 10 per cent.

The variation in the gas pressure in the mains, even in the best-regulated systems, is usually much greater than .1 inch, frequently being 1 inch and more.

**3.** The pressure of gas is regulated by a device known as a **gas-pressure regulator** and also as a *gas governor*. The objects sought in the use of pressure regulators or governors are: (1) economy in the consumption of gas, and (2) steadiness of the lights and the most effective operation of the burners.

There are two systems of gas regulation now in use, called, respectively, the *pressure-regulation* and the *volumetric-regulation* systems. In the first system, a governor is attached to the service pipe at the meter, and the house distributing

pipes contain gas at a constant pressure; in the second system, each burner is supplied with a governor and the pressure in the house pipes is not controlled, being about the same as in the mains.

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### PRESSURE-REGULATION SYSTEM

**4.** For the successful working of the pressure-regulation system, the house pipes must be of such size as to permit an adequate supply to all burners without loss in pressure between the burner and the governor. Where the piping system is very extended, or the pipes are small, the governor should be adjusted to the minimum pressure of the gas in the street mains, and either volumetric burners or suitable check-burners applied. A **check-burner** is a gas burner supplied with a suitable device for regulating the size of opening through which the gas flows to the tip. Ordinary burners can be converted into check-burners by stuffing cotton into the pillar, and where gas that has been properly scrubbed and purified is used, this form of check is fairly satisfactory, but the cotton must be put in with good judgment, so that the proper-sized flame for the tip is developed. It must be noted that the difference in specific gravity of coal gas and water gas makes an appreciable difference in the amount of gas that will flow through a given burner under the same pressure. As coal gas is much the lighter, it will require a smaller check-opening than water gas. Where Welsbach lights and fuel appliances are to be used on the same system of piping as open burners, the governor on the service pipe should be adjusted to the minimum street pressure, usually about 2 inches, and check-burners should then be applied to the open lights. Both Welsbach lights and fuel appliances give best results under high pressure. Thus, a Welsbach lamp adjusted to burn 3½ feet per hour at a pressure of 2 inches will give considerably more light than the same lamp adjusted to burn the same amount of gas at a pressure of 1 inch. In very high buildings the pressure on the top floors will be much higher than on the lower floors. In this case a separate governor must be installed for each floor.

**5.** The ordinary practice is to put the governor on the house side of the meter. This is the proper place for the governor in most cases, as the governor will respond more quickly with an increase or decrease of volume when lights are turned on or off, and it also has a tendency to cushion any slight jumping motion to the gas that the meter may give if it works a little stiff. There is a use, however, for a pressure regulator on the service pipe that may be of importance in some situations. Thus, where services are tapped into mains used for pumping gas from one point to another and where, accordingly, very high pressures are used, a governor of the diaphragm type should be placed in the service pipe, in order to reduce the pressure at the meter to a reasonable amount.

### VOLUMETRIC-REGULATION SYSTEM

**6.** The system of volumetric regulation is free from all the difficulties experienced with the pressure-regulation system. No governors are required on the house pipe or service pipe; the pressure in the house pipes is about the same as in the street main, and it may fluctuate to any extent, provided that it never falls too low to supply enough gas. Under this system every burner has its own governor, and, if the regulators are properly adjusted, each burner will have the proper amount of gas at just the right pressure to enable it to produce light in the most economical manner. While the system of pressure regulation is far more economical than the use of check-burners without other regulation, yet it cannot regulate the pressure and volume with the nicety required for really successful lighting, and given by a properly adjusted volumetric-regulation system. In order to make the volumetric system more efficient than the use of governors with proper check-burners, the volume supplied to each individual tip must be adjusted with the utmost care, so that just the proper amount of gas is burned. As tips frequently become more or less clogged with an accumulation of dust or carbon in a short time, the adjustment is usually far from perfect, and it will then be found in actual practice that the

use of check-burners with a governor will give almost as good results. This shows the importance of proper periodic adjustment, in order to realize the inherent benefit of a volumetric-regulation system.

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### CONTRUCTION OF GAS-PRESSURE REGULATORS

**7.** Pressure regulators for gas are designed to receive gas at a high and variable pressure and to deliver it at a lower, but steady pressure. In principle, they belong to the general class of devices known as automatic reducing valves.

A regulator suitable for large pipes or mains is shown in Fig. 1. It consists of a hollow cylinder or drum *a* that floats in water within the tank *b*. The drum is guided by means of a rod *c* at the top and rollers *d* at the bottom. The gas is brought in through the pipe *e* and is discharged at *f*. The passage of the gas is controlled by the valve *g*, which is attached by a chain to the top of the drum *a*. A very slight increase in the pressure of the gas within the drum and pipe *f* will cause the drum to lift and reduce the opening between the valve *g* and its seat, thus checking the inflow of gas. Similarly, if the pressure should fall, the drum would sink and increase the opening of the valve until the pressure in the delivery pipe rose to the point for which the regulator was adjusted. The pressure in the delivery pipe may be determined by increasing or diminishing the weights at *n*.

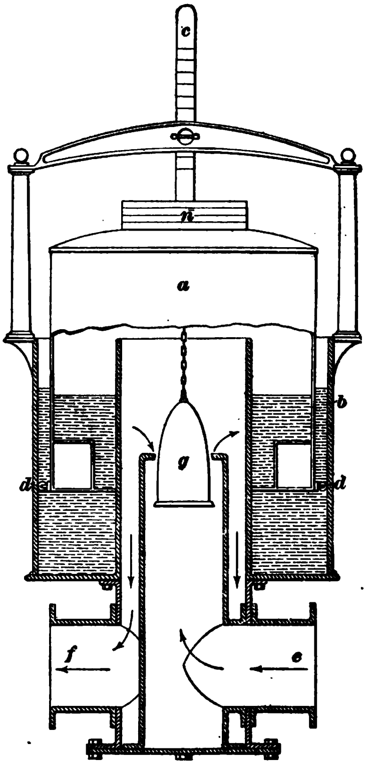

FIG. 1

The pressure in the delivery pipe is not exactly constant with this regulator; but the variation is confined within such narrow limits that the purpose of regulation is accomplished with sufficient accuracy for all ordinary purposes.

Small regulators for domestic use are constructed on the same principle as the regulator just described. Water is unsuitable for small regulators, because it evaporates so easily. In many instances glycerine is used in place of water, since it will not evaporate at any ordinary temperature. Mercury is also used with complete success.

**8.** In another type of gas pressure regulator the floating drum is replaced by a flexible diaphragm *a*, as shown in Fig. 2. This diaphragm rises and falls with the variations in pressure in the delivery pipe, and operates the valve *b* in the same manner as the floating drum in Fig. 1. This kind of regulator is called a *dry governor*, and such governors are used on the gas pipes within the house. Both types of governors illustrated are also made of sufficiently small dimensions to control single gas burners and are frequently united with them in the same structure.

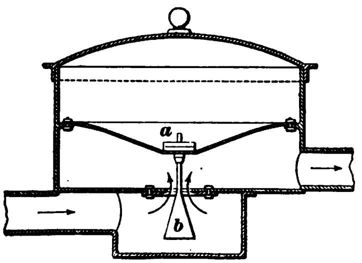

FIG. 2

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#### CONSTRUCTION OF VOLUMETRIC REGULATORS

**9.** A very successful burner containing a *wet volumetric governor* is shown in Fig. 3. The gas passes upwards through the valve seat *a* into the interior of an inverted cup *b*, which floats in glycerine *d*, contained in the lower part of the shell *c*. It escapes from the floating cup through two small holes, which are made of a size that will pass the desired quantity of gas that the burner is intended to consume per hour, at a pressure of .5 inch of water. If the pressure within the cup exceeds that amount, the cup will rise and partly close the valve. It thus maintains the pressure at the tip very

close to .5 inch at all times and insures a steady rate of consumption, although the pressure in the pipes may fluctuate through 20 inches or more.

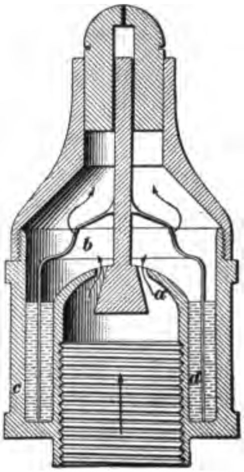

FIG. 3

**10.** One of the most improved forms of *dry volumetric governors* for single gas burners is shown in Fig. 4. The flow of gas to the burner tip is controlled by a tubular valve *a*, which closes against a seat *b*, and which is attached to a very light disk *d*. This disk moves up and down freely, like a piston, in the cylindrical chamber *c*, being guided also by the central post. Gas is admitted freely to the under side of the disk, and a certain quantity is permitted to pass around to the upper side through the hole *e*. The volume of gas passing through this hole may be changed by means of the regulating screw *f*. The weight of the disk and valve is made such that it will require a certain excess of pressure on its under side, say ½ inch, to lift it. When it begins to rise there is nothing to stop its upward movement or to prevent the valve *a* from closing the outlet except the circumstance that as the outlet becomes choked, the pressure above the disk increases until it approximates or equals the pressure below it. The excess of pressure on its under side is thus diminished and is no longer sufficient to hold it up; consequently, it will gradually drop and increase the outlet opening until the pressure above the disk becomes ½ inch less than that below it. Thus, the pressure of the gas escaping past the valve to the burner will always equal the difference in pressure on

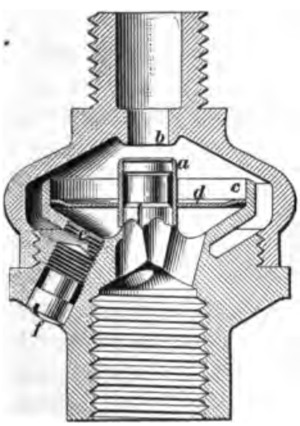

FIG. 4

the upper and lower sides of the disk, in this case about .5 inch; and the volume will depend on the size of the orifice as determined by the screw *f*. By adjusting this screw, the governor can be arranged to deliver gas in any volume within its scope.

**11.** It should be observed that there is a radical difference in the effect produced by the two classes of governors described. The governors shown in Figs. 1 and 2 operate only to regulate the pressure in the delivery pipes; they do not limit or control the volume of the gas passing through. They will pass enough gas to maintain the pressure, no matter whether the amount is 10 feet or 1,000 feet per hour.

The governors shown in Figs. 3 and 4 not only control the pressure of the gas that is delivered to the burner, but they determine the volume, also, with great exactness. The gas is compelled in each case to pass through fixed orifices, which will, of course, pass only a certain volume per hour at the pressure for which they are adjusted. Any attempt to increase or diminish the volume passing, instantly changes the internal pressure and causes the regulating valve to move.

# PIPING BUILDINGS

## INTRODUCTION

### SIZE OF PIPES

**12.** The capacity of each pipe must be great enough to supply all the burners that receive gas through it, when every burner is in full operation. Allowance must also be made for all heating and cooking apparatus, not only for that which is decided on, but for all that is liable to be required.

Service pipes should never be less than $\frac{3}{4}$ inch in diameter, because of the liability to chokage, and it is advisable to make the diameter at least 1 inch if the pipe is of iron. For small cook stoves, the supply pipe should be at least $\frac{3}{4}$ inch in diameter and larger stoves should have pipes from 1 inch to $1\frac{1}{2}$ inches in diameter.

The quantity of gas burned by gas burners varies not only with their construction but also with their condition, and may be as low as $2\frac{1}{2}$ cubic feet per hour and as high as 7 cubic feet, or more. Nothing short of an actual test will give the amount of gas really burned per hour. In installing a gas-lighting system, the required size of the piping must obviously be computed on the assumption that each burner consumes a certain number of cubic feet of gas per hour. Practical experience has shown that the average consumption of various gas burners is about 5 cubic feet, and hence it is customary to install piping systems in accordance with the assumption that each burner consumes 5 cubic feet of gas per hour, unless the specifications under which the work is done specify otherwise.

Having ascertained the probable maximum quantity of gas required in cubic feet per hour, the necessary nominal diameter

of the pipe can be found from Table I. If the length of the proposed pipe exceeds the maximum length given in the table, then the diameter chosen should be the next size larger. If the pressure of gas exceeds 2 inches of water, the principal pipes may be reduced in diameter one size. If the pressure is less than 1 inch of water, then all the pipes must

**TABLE I**

**CAPACITY OF GAS PIPES**

| Diameter of Pipe Inches | Maximum Length Feet | Capacity per Hour Cubic Feet | | Number of Burners Acetylene Gas |
|---|---|---|---|---|
| | | Coal Gas | Gasoline Gas | |
| 3/8 | 20 | 15 | 10 | 3 |
| 1/2 | 30 | 30 | 20 | 6 |
| 3/4 | 50 | 100 | 75 | 20 |
| 1 | 70 | 175 | 125 | 35 |
| 1 1/4 | 100 | 300 | 200 | 60 |
| 1 1/2 | 150 | 500 | 350 | 100 |
| 2 | 200 | 1,000 | 700 | 200 |
| 2 1/2 | 300 | 1,500 | 1,100 | 300 |
| 3 | 450 | 2,250 | 1,500 | 450 |
| 4 | 600 | 3,750 | 2,500 | 750 |

be made one size larger, and in case of very long pipes, the diameter will require to be increased still more.

When carbureted air, which usually is gasoline gas, is used, no distributing pipe should be less than 3/8 inch in diameter. For acetylene gas no distributing pipe smaller than 1/4 inch should ever be used.

Some gas companies issue rules governing the installation of piping systems in buildings supplied with gas by them. Wherever this is the case, the installation should conform with the prescribed rules, copies of which can generally be had free on application at the office of the company issuing them.

The pressure of the gas is assumed in the foregoing table to be about 2 inches of water column. It should be understood that the quantities given are those that the pipes will deliver at the burners without objectionable fall of pressure.

The use of the table is shown by the following example:

EXAMPLE.—What diameter of pipe should be used to supply three ordinary coal-gas burners, the length being 60 feet?

SOLUTION.—The quantity consumed will be $3 \times 5 = 15$ cu. ft. per hour. The table shows that $\frac{3}{8}$-inch pipe can be depended on to deliver that quantity of gas at a distance of 20 ft. only; therefore, it will not serve properly to carry 60 ft. The $\frac{3}{4}$-inch pipe is evidently too large; therefore, the intermediate size—$\frac{1}{2}$ inch in diameter—may be used. Ans.

---

## PIPE FITTING

**13.** The methods of cutting, bending, threading, and jointing gas pipes within buildings are exactly the same as those employed in installing wrought-iron and steel-pipe systems for plumbing and heating purposes. It should be borne in mind, however, that the tightness of all screw joints should depend on the perfection of the screw threads, and not on any red lead or cement that may be used in closing the joints. Therefore, all threading tools should be kept sharp and in strictly good order at all times.

In cutting threads at the pipe vise, the pipe should not project any farther than is necessary to give elbow room while working the dies, because the farther away the dies are from the vise, the greater is the torsional stress on the pipe, and the more liable it is to be strained or split in the butt-welded joint.

It is customary to cut and thread all the pipes required for an ordinary building on the premises where they are used, and to do the work exclusively with hand tools. On large jobs, however, where the gas pipes are larger than 1 inch, a great saving in labor and time can be effected by cutting and threading the large pipes with suitable power-driven machines in the shop, the cutting and threading of only the smaller pipes and the special fitting being done on the premises

where the gas-lighting system is being installed. If the working plans are made with reasonable accuracy, there will be no difficulty in preparing the pipes and fittings at the shop, so that they may be put into their places in the building and screwed together with entire success.

In screwing pipes together, or into fittings, the pipe should be gripped as close to the fitting as practicable so as to prevent the pipe from being split by twisting.

After pipes are cut and threaded, each piece should be carefully inspected to see whether it is free from cracks or splits, and whether its length conforms to the drawing.

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### DRAINAGE OF PIPES

**14.** Illuminating gas nearly always contains a small percentage of watery vapor, which condenses on the interior of the pipe. The condensed water will flow to the lowest point in the pipe, and if no provision is made for its removal, it will accumulate to such an extent as to close the passage and stop the flow of gas. Therefore, all horizontal pipes, unless very short, must be so inclined that they will drain properly. All the branches of a riser must be inclined to drain back into it, or, if the branch is very long, it may be inclined so as to drain into a drip cup at some intermediate point. Usually the whole system of house pipes is arranged to drain back into a drip cup at the meter.

Drip cups must always be located at some point where they can be got at and emptied without difficulty. It is considered good practice to place a plugged **T** at the base of a riser at the cellar ceiling instead of a 90° elbow. Should the riser sag and make a trap at the base, or should rust fall down the riser and choke the base, it can easily be cleared after unscrewing the plug.

Gas pipes composed of lead or other soft metals should not be used in ordinary buildings. If such gas pipes are specified for special work, they must be protected against sagging by running them on a ledge or shelf. Every sag operates as a pocket to collect water, and if the depression

of one of the sags equals the diameter of the pipe, the accumulation of water will eventually choke the pipe and stop the flow of gas.

## INSTALLING THE PIPING

### GAS-FITTERS' PLANS

**15.** The location of gas fixtures is generally indicated on the architect's plans by a star, thus *, and the number of burners on each fixture, together with the height of the fixture above the floor, is stated in the specifications.

To facilitate the work of running the pipes and of estimating their proper sizes, the gas-fitter should make plans of the piping on each floor. An outline tracing should be made of each floor of the building from the architect's plans. On

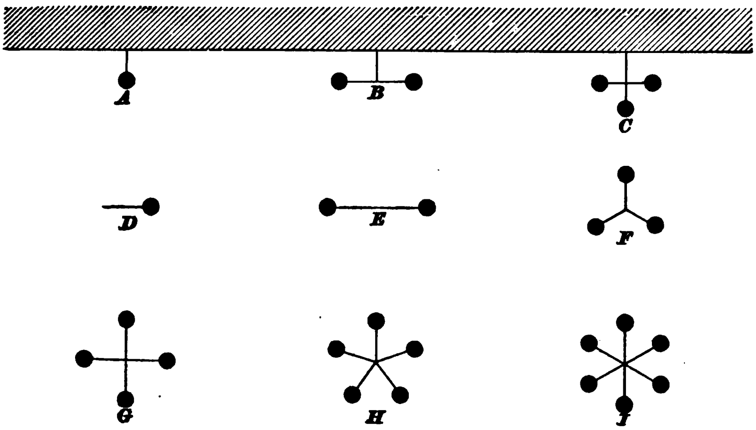


FIG. 5

these should be noted the position of each fixture and its height from the floor, and the number of burners required for each one.

The number of burners and the kind of fixture may be conveniently indicated by the symbols shown in Fig. 5, where *A*, *B*, and *C* represent side lights or brackets having

one, two, and three lights, respectively, each large dot representing one burner. In a similar manner, *D*, *E*, *F*, *G*, *H*, and *I* represent drop lights having one, two, three, four, five, and six burners, respectively.

The horizontal piping should be indicated by plain black lines, and each floor plan should show only those pipes that are to be actually run in the floor of that story or on the under side of it.

The points at which risers or drop pipes are to be connected to the horizontal pipes may be indicated as shown in Fig. 6. Thus, an × at *j* indicates that a drop pipe descends from that point, and a ○ at *k* indicates that a riser ascends from that point. A ○ and × combined, as at *l*, indicate

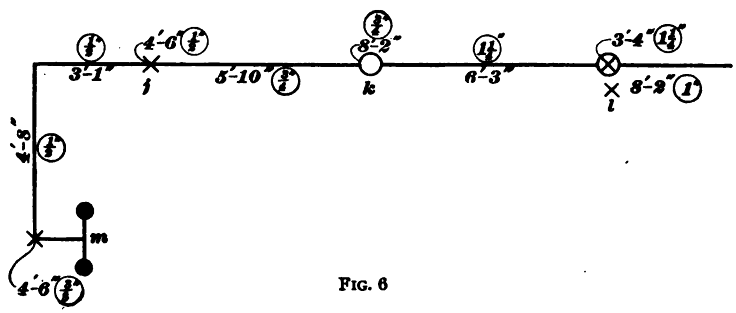
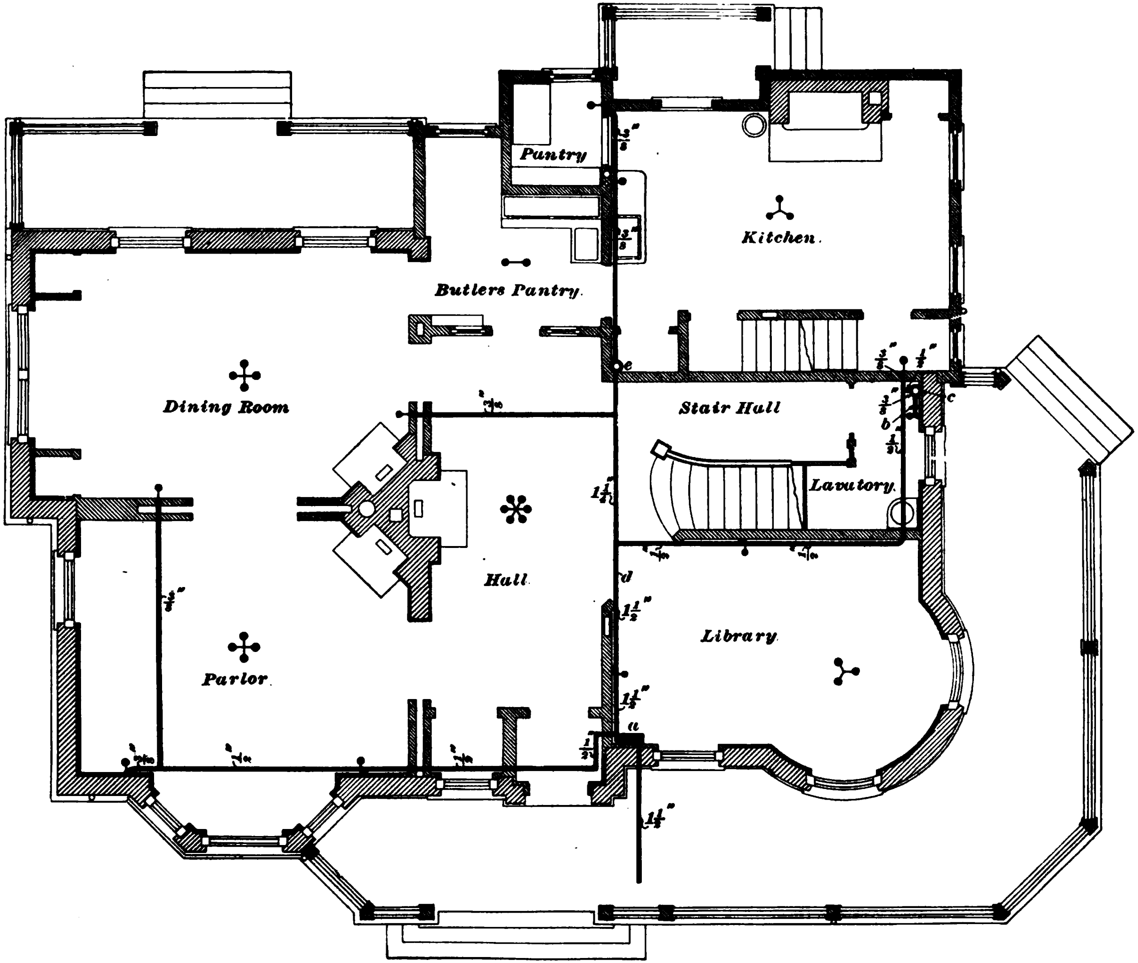



FIG. 6

that the vertical pipe extends both above and below. At *m* is indicated a drop pipe leading to a bracket or side light having two burners.

The length of each pipe should be figured from center to center of fittings, and the diameter should be written close to the figures indicating the length. Thus, the pipe between *l* and *k* is shown to be $1\frac{1}{4}$ inches in diameter and 6 feet 3 inches between centers of fittings.

The length of each riser or drop pipe should be similarly indicated by figures placed near the symbol and connected to it by a light line; thus, at *j* there is a drop pipe $\frac{1}{2}$ inch in diameter, descending 4 feet 6 inches to center of fitting; at *k* there is a riser $\frac{3}{4}$ inch in diameter, ascending 8 feet 2 inches; at *l* there is a riser $1\frac{1}{4}$ inches in diameter, ascending 3 feet 4 inches, and a drop pipe 1 inch in diameter, descending 8 feet 2 inches.



Pantry
Kitchen.
Butlers Pantry.
Dining Room
Stair Hall
Lavatory.
Hall.
Library.
Parlor.


FIG. 7

In order to show which figures belong to the drop pipe at *l*, an × is placed before them, as illustrated. Where figures are crowded, it is advisable to draw a ○ around the figures indicating diameters of pipes, in order to clearly distinguish them from all others.

If any of the vertical pipes require to be offset or bent to pass around obstructions, etc., or a horizontal pipe is to be run along a wall at a height between the floor and the ceiling, a reference letter should be placed conspicuously at that point, and a corresponding note made on the margin of the drawing. A diagram of the special pipe required should be made and attached to the drawing.

Gas-fitters' plans are sometimes made in perspective; but if the work is at all complicated, the drawing is likely to be very confusing, especially if the draftsman is a little unskilful.

The plan recommended in the preceding paragraphs has the advantage that several sets of piping for various purposes may be indicated on the same drawing. Thus, pipes for gas, steam, and water, and tubing for electric wires, may be shown by using differently colored inks for the various systems of pipe.

**16.** Fig. 7 shows the first-floor plan of a common two-story-and-basement dwelling house. The second-story plan is shown in Fig. 8. These figures are supposed to represent tracings from the architect's drawings, with the gas piping drawn in.

The meter *a* is placed in the basement, and all the piping shown on this plan is run along or under the basement ceiling, except *b*, which is a $\frac{3}{8}$-inch horizontal branch to supply the lavatory bracket from a $\frac{3}{8}$-inch riser *c*, run from the basement to the bracket on the stair landing above. A distributing main *d* runs directly from the meter outlet to the riser *e*, and all the branches that supply gas to the brackets of the first floor, also the basement lights, are taken from this pipe.

The chandeliers or pendants that illuminate this floor are supplied with gas from the pipes shown in Fig. 8. These pipes run under the floors and across or between the joists. They also supply all brackets that illuminate the second floor.

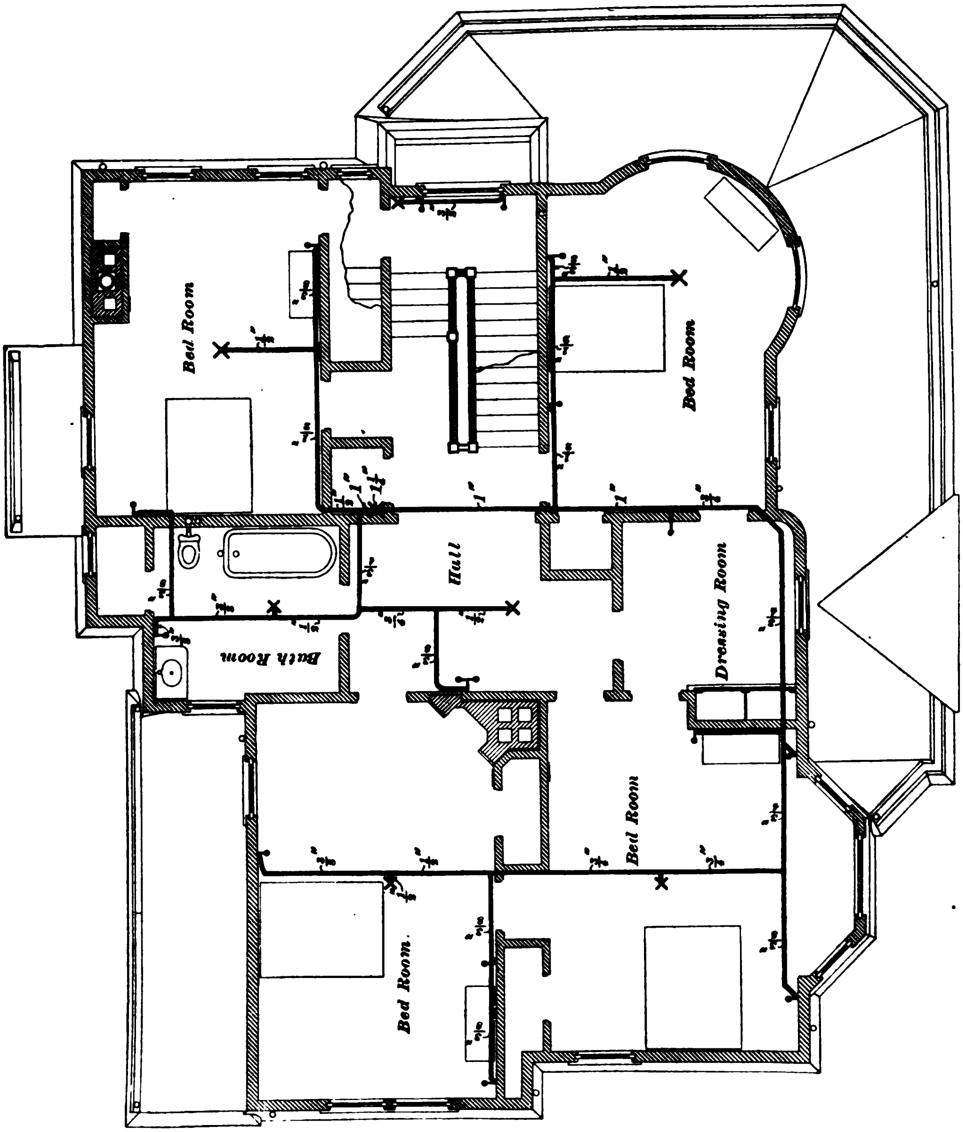

Bed Room
Bed Room
Hall
Bath Room
Dressing Room
Bed Room
Bed Room.

FIG. 8

The pipes are all proportioned to give an abundant supply of gas to the entire building when all the jets are burning at the same time. They are also all laid to pitch back toward the meter, where a drip cup may be placed. The piping in Fig. 8 is so arranged that no floor joists will be cut at a greater distance than 2 feet from a point of support. The joists all run from front to rear of the building.

There are many other ways of running the pipes for this work, but the drawings show a method probably as good as any.

**17.** If the location of the pipes is not shown by the architect, then the gas-fitter must use his own judgment in determining their position. He should be governed by the following considerations: (1) The pipes should run to the fixtures in the most direct manner practicable; (2) the pipes must be graded to secure proper drainage without excessive cutting of floorbeams, or otherwise damaging the building; (3) pipes that run crosswise of floorbeams should be laid not more than 1 foot away from the wall, so as to avoid serious injury to the floor by weakening the beams; (4) fixtures should be supplied by risers rather than by drop pipes, as far as practicable; (5) all pipes should be located where they can be reached for repairs with the least possible damage to the floors or walls.

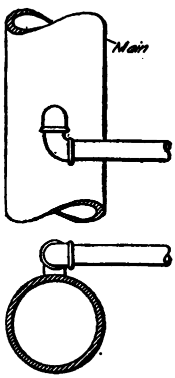



FIG. 9

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SERVICE PIPES

**18.** The pipes that convey the gas from the mains into the building should be connected to the top of the street main, as shown in Fig. 9, and not to the sides or bottom. The hole in the cast-iron main is tapped with a drill and ratchet, held in place by a tapping machine or a clamp, often called a *crowfoot*, or *old man*. The best forms of tapping machine are now arranged with a saddle with a rubber gasket that clamps down on the pipe and through which the drill or tap works. The escape of gas while the work is being done is thus avoided.

The drill or tap is a combined drill, reamer, and pipe tap, so that the hole is tapped out in one operation ready for the fitting to be screwed in. Soap is used on the tap to prevent the escape of gas where machines that have no special device for this purpose are employed. Services should always be connected to the main by two street elbows, one being screwed into the hole in the main and turned in the direction of the run of the pipe, and the other being screwed into the first and turned toward the house. A form of universal joint is thus made and there is no danger of straining or breaking pipe or fittings when the ditch is filled.

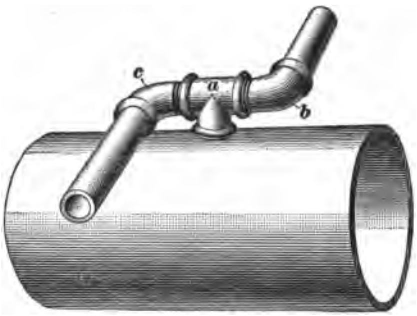

FIG. 10

**19.** Where it is desirable to run two services from the same tap to opposite sides of the street, a street tee *a*, Fig. 10, and two street elbows *b* and *c* are used, the street tee being screwed into the pipe so that the two ends look up and down the run of the main.

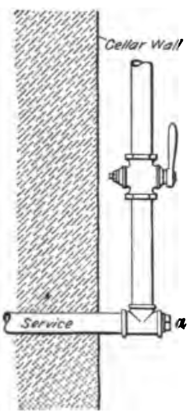

FIG. 11

**20.** A tee should be placed on the service at the first turn it makes after it comes through the cellar wall, as shown in Fig. 11, the fitting being so placed that the plug *a* can be removed and a wire or rod run into the pipe toward the main for clearing purposes.

**21.** Services should never be laid in a ditch above water or sewer pipes, as such a ditch is almost sure to settle enough to trap the service pipe. Where it is desirable to lay the service in the same excavation with other pipes, a shelf of solid ground should be left on one side of the ditch and the gas service laid on this, as shown in Fig. 12.

**22.** Great care should be taken to lay service pipes with an even inclination toward the street main, if possible; if this cannot be done, they should incline toward the house, in which case a suitable drip cup must be provided on the house end, as shown at *a*, Fig. 13. Services should be carefully bedded on firm ground, so that there will never be any chance of the pipe settling and forming a trap.

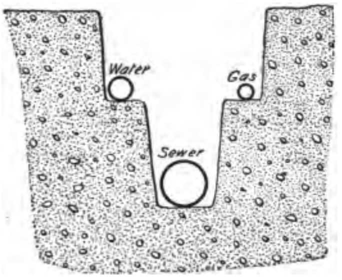


FIG. 12

**23.** A shut-off cock should be placed in every service pipe at the curb, and this should be enclosed in a suitable box extending upwards to the surface of the pavement, and closed against the entrance of dirt, water, or snow by a tight cover.

A curb box is shown in Fig. 14. A round-way stop-cock *a* is placed in the service pipe *b*. The service pipe is properly

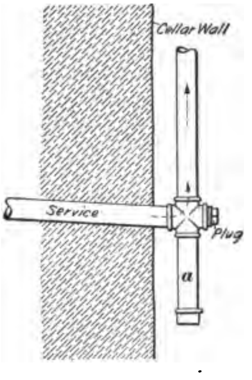


FIG. 13

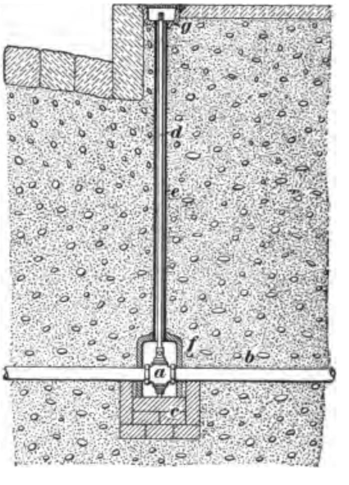


FIG. 14

lined up and a brick support *c* is built under it, the pipe at each side of the stop-cock resting on the bricks. The rod *d*

is made of such a length that its top end is about 2 inches below the surface of the sidewalk. The lower forked end of the rod is bolted to the key of the cock. The rod casing tube *e*, made usually of 1-inch or 1¼-inch pipe, is cut to such a length that, with the cast-iron cock casing *f* resting on the brickwork, the flange of the cast-iron curb box *g* finishes flush with the surface of the sidewalk. The square end of the rod *d* should project inside the box at least 1 inch, so that the rod may be turned by a box key. The cover of the curb box should be hinged, and preferably be capable of being locked. The casing pipe *e* should be screwed both into the curb box and the cock casing.

**24.** The hole in the wall through which the service pipe enters the cellar or basement should be larger than the pipe, so that the settlement or shifting of the ground outside will not cause the pipe to bind or strain in the hole.

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### CONNECTIONS TO METERS

**25.** The connection from the meter to the service pipe and also to the house pipe should be made with lead or other soft-metal tubing, as shown at *a*, Fig. 15. These connections will bend and relieve the couplings on the meter from injurious strains in case the pipes expand or contract, or are displaced by the settlement of the building, etc.

Meters are usually set on a shelf, but this is not necessary unless the meter is large and heavy. If the meter is of the wet type, then it must be supported on a shelf and the shelf must be carefully leveled both lengthwise and crosswise. The dry meters now in common use do not require leveling in order to work properly, but they should always be set plumb for the sake of appearance and as a matter of good workmanship.

**26.** A single service pipe may supply two or more systems of distributing pipes, as shown in Fig. 15. Each meter must be provided with a shut-off cock, as at *b* and *c*, and drip cups should be attached to each line of house pipes, as at *d* and *e*. The service pipe should also have a drip cup,

unless it is inclined so as to drain into the street main. A drip for the service pipe is shown at *f*. If several meters are used in the same building, they should be placed on a shelf, in one group if practicable, and all the connections should be made exactly alike, so as to present a neat and orderly appearance. When gas is used for fuel in addition to lighting, it is often required that the two supplies be measured

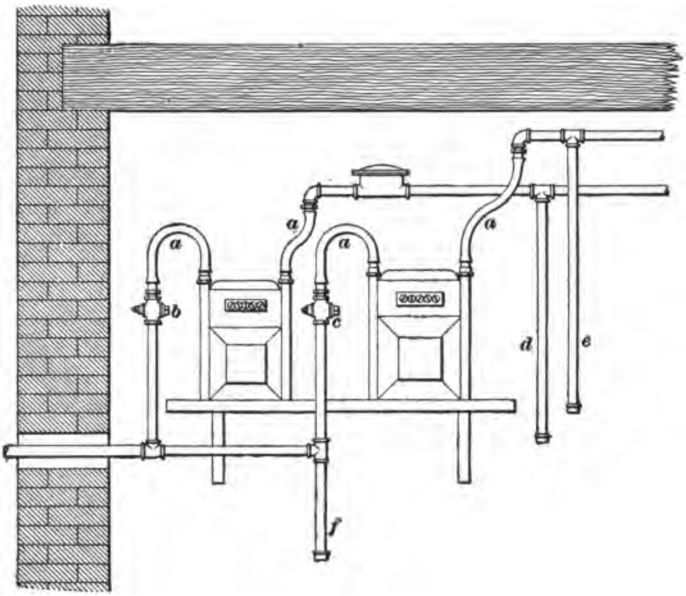


FIG. 15

separately, in order to determine the actual expense for each purpose. Some gas companies furnish gas for fuel at reduced rates, to induce consumers to put in cooking apparatus, and also to increase the sale of gas. If the price of gas is the same for all uses, and it is not desired to keep a separate account of that used for fuel, then one meter is sufficient to measure the entire supply.

### ORDER OF OPERATIONS

**27.** The proper way to pipe an ordinary building for gas is as follows:

The gas-fitter should visit each floor of the building with the plans in hand, and should mark the location of each drop for a hanging fixture, and of each side light or bracket.

Having thus acquired a clear idea of the location of each fixture, the next thing to be decided is the best route for the distributing pipes. If there are other pipes in the building, for water or steam drainage, care should be taken to avoid conflict with them, and the risers for gas should be placed along with the other risers, unless they are an inconvenient distance away. Pipes for the various purposes of heating, lighting, etc. should not be scattered promiscuously over a building, but they should be kept together as much as practicable.

The matter of drainage should next be considered. Each branch must drain back into its riser and the whole system should drain back to the meter. Long branches which run crosswise of the floorbeams should be avoided, because the notches that must be cut in the beams to give the necessary drainage become too deep and are then very objectionable.

Working plans of the piping on each floor should next be made for use at the pipe vise. The proposed route for each pipe should then be inspected to see whether the pipes can be got into place without difficulty, and whether right-and-left connections are required, and if so, where they must be placed.

The roads for the various pipes should next be marked off, taking the carpenter along and explaining to him the depth to be given to the notches, and to cut the timbers in such manner as not to weaken them; he should also be fully instructed where and how to build the supports for the hanging fixtures. If the walls are of brick, the necessary pockets for rising pipes, if any, should be marked off, and the proper places for cutting holes through the walls, etc. should be carefully marked and shown to the mason.

**28.** Leaving the carpenter or mason to prepare the roads for the pipes, work may begin by setting up the pipe vise and getting the tools ready.

Each piece of pipe should then be inspected to see whether it is free from obstruction and dirt. The several pieces of pipe are next cut and threaded according to measurements on the working plan, and the fittings screwed on while the pipe is in the vise. The various pipes should then be carried to their respective floors and laid in convenient places.

Erection may begin by fitting up the main riser. The various branches should then be extended, working always from the riser toward the outlets. Cement or red lead should be used very sparingly and care should be taken that no lumps or clots of it run down into the inside of the pipes.

Elbows, tees, and other fittings should stand clear from the studding and joists, whenever practicable, so that all the joints may be accessible for the purpose of testing.

Changes in the direction of small pipes should be made by bending the tube, if practicable, instead of using an elbow. Elbows and other fittings to which side lights or brackets are attached should be provided with flangers or lugs and should be firmly secured with screws to solid woodwork, or, in case of brick walls, to wooden plugs driven into holes drilled in the wall, or to wooden blocks imbedded in the wall for that purpose, so that the fixture will be rigid.

The nipple for a side light or bracket should project from the wall at right angles a distance of not less than $\frac{3}{4}$ inch, and not more than $1\frac{1}{4}$ inches. The nipple should be screwed tightly into the fitting and a cap should be screwed on the outer end of it. This cap should be screwed up with only a moderate force, so that it can be easily removed at any time without danger of loosening the nipple from the fitting.

Drop nipples that are to support chandeliers or other hanging fixtures should hang perfectly plumb, and in case of a flat ceiling should project from $\frac{3}{4}$ inch to $1\frac{1}{4}$ inches from the surface. If ornamental center pieces of plaster, etc. are to be used, the necessary extra length of the nipple should be ascertained from the architect or contractor.

**29.** The proper manner of supporting a hanging fixture is shown in Fig. 16. The weight of the fixture is carried by the wooden block *a*, which must be made strong and be well secured to the joists *b*. The lower block *c* serves to guide the drop piece *d* and prevent it from swinging in any direction. Care should be taken to make the drop piece perfectly plumb.

**30.** When the nipples or drops for the fixtures are all in place, they should be tested to find whether they are square or plumb. This may be done by attaching a straight piece of pipe 1 foot or so long to which the square and level may be applied, or a plumb-bob may be used alongside of the piece of pipe.

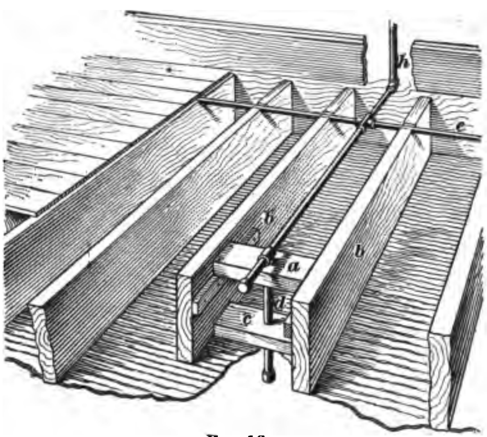


FIG. 16

**31.** The gas pipes should be placed in a new building as soon as the walls are up and the rough timbers of the floors and partitions set, but before the floors are laid or the lathing done. When a gas pipe runs parallel with the floor boards, as shown at *e*, Fig. 16, the board that covers the pipe should have the lower flange of the groove removed, so that it can be readily taken up when desired. If the pipe runs crosswise of the floorboards, a loose piece should be provided in the floor over all principal elbows or tees, so that they can be reached easily in case of repairs or leakage. The loose boards and covers should be fastened in place with $2\frac{1}{4}$-inch screws. Brass screws are frequently used for that purpose, as they will not rust fast.

### EXPOSED PIPES

**32.** Gas pipes should not be exposed to the weather, if possible to avoid it, and care must be taken to protect them from freezing winds or air-currents. Moisture in the gas will condense on the interior of the pipe and form ice and the deposit will increase in thickness until the pipe becomes choked. Exposed pipes should be covered with hair felt or other good non-conducting material, which should be made thoroughly waterproof by a covering of painted canvas. Good protection is especially necessary if the pipe contains carbureted air, which is usually gasoline gas.

Iron gas pipes should not be allowed to touch lead pipes or electric wires that run crosswise or near them, because the continual shifting caused by changes in temperature will ultimately wear a groove or thin spot in the softer pipe, and the insulation of the electric wire will be cut through, thus making a ground or short circuit.

If a metal pipe runs within 2 inches of an electric wire, they should be separated by a non-conductor of some description. For example, the pipe may be wrapped with four or five layers of rubber tape.

### TESTING A SYSTEM OF PIPES

**33.** As soon as the pipes are all in place and are properly secured, the system should be tested to find whether it is perfectly gas-tight. The instruments used for this purpose are a *proving pump*, a *pressure gauge*, and an *ether cup*.

The **proving pump** is shown in Fig. 17. It is a single-acting piston pump having an inlet valve at the bottom that admits air under the piston, and an outlet or check-valve at *b*. The socket *a* of a special bracket is attached to a nipple on the pipe system that is to be tested. The pump is connected to the bracket by means of a stout rubber hose *c*, which must be wired to the coupling tails to prevent it from being blown off by the air pressure. The cock *e* serves to connect or shut off the pump from the pipe system, but does not shut off the gauge.

The **ether cup** consists of a small funnel on the bracket at *d*, which is closed by a thumbscrew. This is for the purpose of introducing ether to make a pungent odor in the interior of the pipes.

The pressure is shown by a mercurial gauge *f*, or by a common steam gauge *g*. The mercury column is to be preferred to the steam gauge, because its operation is positive at all times and it always indicates the true pressure in the system.

Steam gauges, or similar contrivances are not perfectly reliable pressure indicators, their moving parts being liable to stick fast, so that slight pressure variations are not always indicated on the dials.

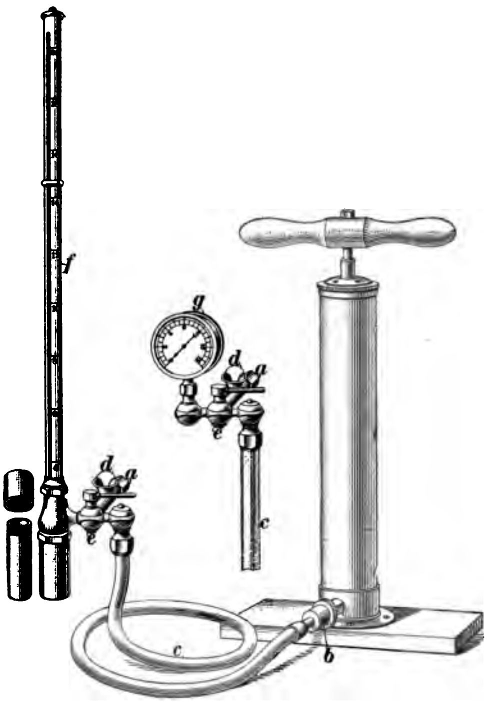

FIG. 17

**34.** To make the test, a convenient nipple should be selected for making an attachment to the proving pump; and every other nipple and open end should be tightly closed by screw-caps. Plugs driven into the ends of pipes will not answer the purpose.

The pump and pressure gauge may then be connected to the system and made tight. Air should be forced in until the gauge indicates 15 or 20 inches of mercury, or from 7 to 10 pounds per square inch. The pump should now be shut off, leaving the gauge under pressure. The pressure should

be continued in the pipes for about an hour, and if the gauge shows a falling off in pressure of more than ½ inch of mercury, or ¼ pound per square inch, the system cannot be passed as perfect.

The extent of the leak may be judged by the rapidity of the fall in pressure, but its location must be found by the sense of smell. For this purpose, a small quantity of ether should be introduced into the pipes. The pressure gauge is usually provided with an ether cup especially for testing purposes. If none is at hand, a cap must be taken off somewhere near the pump and the pressure let off. The ether may then be poured directly into the pipe and the cap replaced as quickly as possible. The pressure should now be pumped up as before. The odor of the ether will diffuse throughout the system of piping and will escape from the leak; thus the location of the leak will be revealed by the smell of ether.

To locate the leak, it is necessary to go over the pipe system, carefully smelling each joint and suspected pipe or fitting. When a suspicious place is found, it should be daubed over with a thick solution of soap, and if any air is escaping at that point it will show itself by making soap bubbles.

Every leak that can be detected should be marked with chalk and the pressure may then be let off. All defective pipes or fittings should be removed and replaced with perfect ones. Patching should rarely be permitted. However, if the defective fitting is a large one, and its removal will be very difficult and expensive, and the leak be but a small sand hole, it may be patched. Gas-fitters' cement, which is only a coarse grade of sealing wax, is not proper material for that purpose. The hole should be closed with solder; or, better still, the hole may be drilled out and tapped to receive a small screw plug. The drilling of the hole will reveal the character of the metal as to whether it is solid or porous. If it appears porous or spongy, the fitting should be thrown out and replaced with a sound one without further delay.

If fittings are cracked, they should in all cases be removed. Cracked or split pipes should always be removed; it is useless to try to patch them.

After making all required changes, the pressure should again be applied, the test being repeated until, with a pressure of at least 15 inches of mercury, the gauge will show not more than ½-inch loss per hour, as before described. If the system of piping is extensive, only one-half of that fall of pressure may be allowed. The gas-fitter should aim to have none at all, and on a really high-class piece of work, the mercury column should stand all night without showing any appreciable fall in the morning.

In case of large buildings, the piping should be tested in sections, say one floor at a time, since in this way it is much easier to locate leaks. After each section is tested, they may be connected, and then subjected to a final test.

The pipes should not be covered until the tests are completed. Usually the gas companies or the city authorities require that the testing be done in the presence of their inspector. If no such regulations are in force, then the owner or architect should witness the tests, so as to avoid any possible disputes.

**35.** Ether is a dangerous fluid to handle, especially if there are any fires or lights in the vicinity. Cigars and pipes must be banished, and great care must be taken to avoid spilling any ether, or getting it on the hands or clothes, because if the odor is thus set free in the building, it will be difficult to detect leaks in the pipes. Other substances may be used that are free from the danger of fire, such as the essential oil of peppermint (not the essence), but they are not so volatile and do not diffuse throughout the pipes so readily.

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## DEFECTS AND THEIR REMEDIES

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### GENERAL REMARKS

**36.** The troubles experienced with gas-piping systems, and that gas-fitters are commonly called on to remedy, may be broadly divided into troubles occurring in the gas-supply

pipes and troubles with the fixtures, as the burners. Mainly those occurring in the gas-supply pipes will be treated of here.

The most prevalent source of trouble are *leaks*, which may occur in any part of the pipe system or in the fixtures, and manifest themselves by a strong odor of gas. Leaks are liable to occur in the most unexpected places, and often a careful, painstaking, and systematic search of the whole piping system within and without the building is required to discover them.

Chokage of the supply pipes is another fruitful source of trouble; it is caused by foreign matter being carried into the supply pipes and manifests itself by a reduction of the gas supply, as shown by the burners giving a steady but very small light.

Water in the gas supply pipes manifests itself by a flickering and jumping of the lights, which at times may be so bad as to render them almost useless. In extremely cold weather the water collected in sags and bends in the pipes may freeze and thus partly or entirely shut off the gas supply either from part or the whole of the building. The gas supply is then said to be frozen up.

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## LEAKS

**37.** The repairing of gas leaks is dangerous business, because any mixture of common illuminating gas with air in the proportion of 13 parts of air or less to 1 part of gas will explode if it comes in contact with fire of any kind. If the explosive mixture is richer in gas than 1 to 13, it will explode with proportionately greater violence.

Before entering a room that smells strongly of gas, all lanterns or torches must be extinguished and cigars or tobacco pipes must be left behind. All matches should be laid aside, because the workman is liable, in a moment of thoughtlessness, to strike a light to "see where he is," and thus produce an explosion.

If the place is very dark, and a light is required, a coal-miner's safety lamp should be used. Even these lamps must

be used with caution. The necessary instructions for handling them are furnished with the lamps.

Occasionally there is a risk of being suffocated or overcome by the gas, and the gas-fitter should always have an assistant within sight who can help him out in case of accident. If he begins to feel dazed or *queer* while breathing the vitiated air, he should drop to the floor and make his way out on hands and knees. The air near the floor is likely to be nearly free of gas, thus giving him a chance to breathe.

In beginning a search for a leak, the first thing to do is to shut off the gas at the meter, or, if that cannot be reached safely, it may be shut off at the curb. Then the windows and doors should be opened, and every effort made to free the premises from the presence and odor of gas.

All places that cannot be readily ventilated, such as the upper parts of closets, small hallways, space under stairways, etc., should be thoroughly fanned out, the vitiated air being driven into the air-currents that will carry it off. The space between the floors may be filled with gas, and sometimes it is necessary to make openings and circulate air through them to clear out the gas.

If the apparent proportion of gas in the air does not plainly diminish when the supply is shut off at the meter, then the leak is probably in the service pipe outside of the building. It may be that the leak is in the main, and that the escaping gas follows the service pipe and enters the premises through the pipe hole in the cellar wall. In loose or made ground, the gas from a leak in the street will sometimes follow a water pipe into the cellar.

After the premises are cleared of the odor, the gas should again be turned on at the meter.

Ordinarily, the leak can be located approximately by the odor of the gas that again escapes from it. If there is no plain indication of its source, then a systematic search must be made. The first point to be examined for leakage, in the system of house pipes, is at the meter. Leaks may occur in the meter casing or around the glass cover over the register

dials. If a defect is found here, the meter should be removed and a sound one put in place. A small leak may be stopped temporarily by the use of hard soap as a cement; but this cannot be depended on to remain tight for more than a few days. The meter connections should then be examined, and if the couplings are found to be leaking, they should be supplied with new packing washers. The gas fixtures should next be examined, care being taken to ascertain positively the tightness of every cock or key. Leaks may occur at the swing joints and at the base of the burners, but these will be perceptible only when the fixture is in use. Chandeliers and pendants should be examined at the connection to the drop nipple overhead, and at the ball joint, if there be one.

All stuffingboxes on sliding or extension fixtures should be closely examined. Leaks may also be looked for at either end of the nipple at brackets or side lights.

If no leak is found at the meter or fixtures, then the defect is evidently in the pipes or fittings, and the only practicable method of finding it is to prove the pipe system, as directed in Art. **34**.

The use of matches to detect small leaks of gas is a dangerous practice; they should never be used in any place where there is a chance for escaping gas to accumulate and mix with air. Smearing the pipe with thick soapsuds is more certain to reveal small leaks, and is free from danger.

If no leak can be found on the premises, and the odor of gas still exists, it is probable that the leak is in some other pipe system, and that the gas is conducted into the premises through some unsuspected channel, such as accidental passageways between floorbeams, rat holes, loose spaces around water pipes, etc.

### CHOKAGE

**38.** When gas pipes become choked, they may be cleared in most cases by blowing them out with compressed air. An ordinary air pump is used to compress air into a strong storage tank, and when a sufficient pressure has been accumulated, the tank is connected to the choked pipe, and the air is

discharged into it as suddenly as possible, thus blowing out all obstructions before it. The air pump and storage tank are generally combined into a portable hand-operated apparatus, one form of which is shown in Fig. 18, and is known as a **service cleaner.** The bulged part, or base, forms the air-storage tank and has a hand pump attached to it by which air is pumped into the base. The stop-cock at the bottom is connected by means of a rubber hose to the gas-pipe system. Air having been compressed into the base, a sudden opening of the stop-cock results in blowing suddenly a large volume of air into the gas-pipe system.

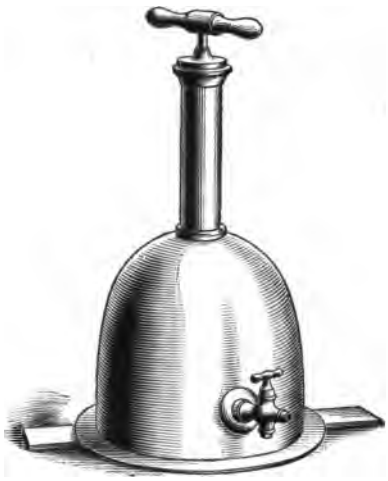

FIG. 18

When a service pipe is choked, or trapped with water, it is disconnected from the meter, and air is quickly forced through toward the main. If the pipes in the building are choked, the gas fixtures affected by the chokage are taken down, and air is rapidly forced through their supply pipes, so that the obstructions will be blown out at the open ends of the drops.

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### FLICKERING LIGHTS

**39.** The flickering and jumping of gas lights is caused by the presence of water in the pipes. The liquid accumulates in sags and low places, and fills the bore of the pipe, forcing the gas through it in a series of bubbles. As each bubble escapes, the water is agitated, and the lights jump in response to the momentary fluctuation of pressure. This trouble can be remedied by emptying the drip cups and taking care to thoroughly drain all parts of the pipe system. Sometimes the deposit of water will be found in the fixture instead of

in the supply pipes, especially if it is a pendant or chandelier. A water trap will frequently be found in the service pipe.

A similar effect is caused by a wet meter that is drowned or flooded by too much water. In this case the trouble may be overcome by drawing off the excess of water.

Dry meters that are stiff and need cleaning and oiling, or in which the arms have not been connected to the rock shaft at the proper angle, may cause the gas flames to flicker.

Dry meters are sometimes troubled with the water condensed in the pipes; they are usually provided with trap screws, so that the water can be easily removed when necessary.

The apparent freezing up or choking of the gas supply in extremely cold weather is due to the exposure of the pipe at some point to a draft of very cold air or to a freezing wind, the consequences of which were described in Art. **32.**

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## RULES AND REGULATIONS FOR GAS PIPING AND FIXTURES

**40.** The following are the rules and regulations governing the illustration of gas piping and fixtures in buildings in the City of New York, effective April 23, 1913:

### Gas Piping and Fixtures

**176.** Hereafter the gas piping and fixtures in all new buildings and all alterations and extensions made to the gas piping or fixtures in old buildings must be done in accordance with the following rules, which are made in accordance with the provisions of Section 89 of the Building Code.

For additional requirements of public buildings, theaters, and places of assemblage, see Part XXI of the Building Code.

177. Before the construction or alteration of any gas piping in any building or part of any building, a permit must be obtained from the Superintendent of Buildings. This permit will be issued only to a registered plumber. Small alterations may be made by notifying the Bureau of Buildings, using the same blank forms provided for alterations and repairs to plumbing.

178. All gas pipe shall be of the best quality wrought iron or steel and of the kind classed as standard pipe, and shall weigh according to the following scale:

| Diameters Inches | Weights per Linear Foot Pounds |
|---|---|
| $\frac{3}{8}$ | .56 |
| $\frac{1}{2}$ | .85 |
| $\frac{3}{4}$ | 1.12 |
| 1 | 1.67 |
| $1\frac{1}{4}$ | 2.24 |
| $1\frac{1}{2}$ | 2.68 |
| 2 | 3.61 |
| $2\frac{1}{2}$ | 5.75 |
| 3 | 7.54 |
| $3\frac{1}{2}$ | 9.00 |
| 4 | 10.66 |

No pipe allowed of less than $\frac{3}{8}$ inch in diameter.

179. All fittings except stop-cocks or valves shall be of malleable iron.

180. There shall be a heavy brass straightway cock or valve on the service pipe immediately inside the front foundation wall. Iron cocks or valves are not permitted.

181. Where it is not impracticable so to do, all risers shall be left not more than 5 feet from front wall.

182. No pipe shall be laid so as to support any weight except fixtures or be subjected to any strain whatsoever. All pipe shall be properly laid and fastened to prevent becoming trapped, and shall be laid, when practicable, above timbers or beams instead of beneath them. Where running lines or branches cross beams, they must do so within 36 inches of the end of the beams, and in no case shall the said pipes be let into the beams more than 2 inches in depth. Any pipe laid in a cold or damp place shall be properly dripped, protected, and painted with two coats of red lead and boiled oil or tarred.

183. No gas pipe shall be laid in cement or concrete unless the pipe or channel in which it is placed is well covered with tar.

184. All drops must be set plumb and securely fastened, each one having at least one solid strap. Drops and outlets less than $\frac{3}{4}$ inch in diameter shall not be left more than 1 inch below plastering, center pieces, or woodwork.

185. All outlets and risers shall be left capped until covered by fixtures.

186. No unions or running threads shall be permitted. Where necessary to cut out to repair leaks or make extensions, pipe shall be again put together with right and left couplings.

187. No gas-fitters' cement shall be used, except in putting fixtures together.

188. All gas brackets and fixtures shall be placed so that the burners of same are not less than 3 feet below any ceiling or woodwork, unless the same is properly protected by a shield, in which case the distance shall not be less than 18 inches.

No swinging or folding gas brackets shall be placed against any stud partition or woodwork.

No gas brackets on any lath and plaster partition or woodwork shall be less than 5 inches in length, measured from the burner to the plaster surface or woodwork.

Gas lights placed near window curtains or any other combustible material shall be protected by a proper shield.

189. Gas outlets for burners shall not be placed under tanks, back of doors, or within 4 feet of any meter.

190. All buildings shall be piped according to the following scale:

| Diameters Inches | Length Feet | No. Burners |
|---|---|---|
| $\frac{3}{8}$ | 26 | 3 |
| $\frac{1}{2}$ | 36 | 6 |
| $\frac{3}{4}$ | 60 | 20 |
| 1 | 80 | 35 |
| $1\frac{1}{4}$ | 110 | 60 |
| $1\frac{1}{2}$ | 150 | 100 |
| 2 | 200 | 200 |
| $2\frac{1}{2}$ | 300 | 300 |
| 3 | 450 | 450 |
| $3\frac{1}{2}$ | 500 | 600 |
| 4 | 600 | 750 |

191. Outlets for gas ranges shall have a diameter not less than required for six burners, and all gas ranges and heaters shall have a straightway cock on service pipe.

192. When brass piping is used on the outside of plastering or woodwork, it shall be classed as fixtures.

193. All brass tubing used for arms and stems of fixtures shall be at least No. 18 standard gauge and full size outside so as to cut a full thread.

All threads on brass pipe shall screw in at least $\frac{5}{16}$ of an inch. All rope or square tubing shall be brazed or soldered into fittings and distributors, or have a nipple brazed into the tubing.

194. All cast fittings, such as cocks, swing joints, double centers, nozzles, etc., shall be extra heavy brass. The plugs of all cocks must be

ground to a smooth and true surface for their entire length, be free from sandholes, have not less than $\frac{3}{4}$ of an inch bearing except in cases of special design, have two flat sides on the end for the washer, and have two nuts instead of a tail-screw. All stop-pins to keys or cocks shall be screwed into place.

195. After all piping is fitted and fastened and all outlets capped up, there must be applied by the plumber, in the presence of an inspector of the Bureau of Buildings, a test with air to a pressure equal to a column of mercury 6 inches in height, and the same to stand for 5 minutes; only mercury gauge shall be used. No piping shall be covered up, nor shall any fixture, gas heater, or range be connected thereto until a card showing the approval of this test has been issued by the Superintendent of Buildings.

196. No meter will be set by any gas company until a certificate is filed with them from the Bureau of Buildings certifying that the gas pipes and fixtures comply with the foregoing rules.

### Modifications

197. When for any reason it may be impracticable to comply strictly with the foregoing rules, the Superintendent of Buildings shall have power to modify their provisions so that the spirit and substance thereof shall be complied with. Such modifications shall be indorsed upon the permit over the signature of the Superintendent of Buildings.

# DOMESTIC USES OF GAS

(PART 1)

## GAS LIGHTING

### PRODUCTION OF FLAME

**1.** Broadly speaking, the production of any flame involves first the production of gas from a solid or a liquid substance. In the tallow candle, the tallow is first volatilized by the heat from the flame and the resulting gases are then consumed by combination with the oxygen of the air. In the combustion of coal, the volatile constituents of the coal are distilled by heat and burned in the firebox.

So a tallow candle, an oil lamp, a pine torch, or the furnace of a steam boiler is really a gas plant in which the gas is used at the place in which it is produced. A coal-gas plant differs from these only in the basic particular that the gas is driven off without being allowed to come into contact with a naked flame, which would ignite it, and is distributed through pipes to the point at which it is to be consumed.

**2. Combustion of Gas.**—Ordinary illuminating gas is a mixture of several compounds of carbon and hydrogen, which vary somewhat in their composition. The process of combustion consists in the decomposition of these compounds by means of heat and the formation of new compounds by combining the carbon and hydrogen separately with oxygen. The carbon and oxygen unite and form carbon dioxide, also called carbonic acid, which is indicated by the symbol $CO_2$. The hydrogen

and oxygen unite and form water, indicated by the symbol $H_2O$; the water is in the form of vapor. A large amount of heat is given off during the formation of these compounds; but, owing the the mixed composition of ordinary illuminating gas, it is somewhat difficult to calculate the heat developed by its combustion.

**3.** If the composition of the gas is known and the actual weight of a given quantity can be ascertained, the heat in British thermal units may be computed by assigning to each pound of combustible substance the following amounts: Hydrogen, burned to water, $H_2O$, 62,000; carbon, burned to carbon dioxide, $CO_2$, 14,600; carbon, burned to carbon monoxide, $CO$, 4,400; carbon monoxide, burned to carbon dioxide, $CO_2$, 10,200.

Before gas can be burned, its temperature must be raised to the point of ignition; a part of the heat produced by combustion, therefore, is always absorbed in preparing the cold gas and air for burning. Combustion is not instantaneous in any case, because an appreciable interval of time is always required to bring the gas and air up to the required temperature.

**4.** The temperature of a gas flame depends on the amount of gas burned within a given space and time, and also on the temperature of the gas and air at the moment of entering the burner. Thus, if the size of a flame is reduced by affording a better supply of air to the gases, so as to consume them more quickly, and therefore in a smaller space, and the amount of gas burned remains the same, the temperature will be correspondingly increased.

If a jet of gas is ignited in the ordinary atmosphere, the flame will spread out until the surface presented to the air becomes large enough to take up the oxygen required for combustion with sufficient rapidity to consume the gas as fast as it issues from the burner. The surface of the flame thus extended is so large, in proportion to the quantity of gas actually burning, that the heat is radiated and imparted to the surrounding air with great rapidity, and the temperature of the flame is low in consequence. If the flame is large, some of the gas will be cooled below the point of ignition before it can

secure the oxygen necessary for combustion, and will fail to burn; a smoky flame will then result.

**5.** The temperature of a gas flame may be increased by placing a chimney over or around the flame. The supply of oxygen is increased by the draft thus created and the size of the flame is reduced; moreover, the chimney helps to confine the heat from the flame by restricting radiation, thus increasing the temperature.

Gas flames produced by simple jets of gas unmixed with air are usually unprotected by glassware and are then referred to as **open flames**; because of their color, they are also often called **yellow flames.** On account of the large surface of such flames in proportion to the amount of gas burned, heat is radiated rapidly, causing a considerable reduction in temperature. The size of the flame is due to its tendency to spread out until the surface presented to the air is sufficient to permit enough oxygen to be taken up to consume the gas as rapidly as it issues from the burner.

**6.** If a portion of the necessary air is mixed with the gas before combustion, it will not be necessary for the flame to spread out so widely to gather oxygen, hence the size of the flame will be reduced. This mixing of air and gas may be secured by utilizing the velocity of the gas as it issues from a small orifice to suck in or entrain air through air ports surrounding the orifice. This mixture may then be carried through a tube until well mixed, and then burned. Burners utilizing this principle are called Bunsen burners, from the name of the inventor, and the flames produced are known as Bunsen flames or as blue flames, on account of their blue color. Bunsen burners produce a flame of very high temperature and are used in practically all gas-burning appliances where high temperature is an important consideration.

Gas-lighting burners are of two types, those in which the flame itself is luminous and those in which the flame is non-luminous, a permanent incandescent material being provided to utilize the heat of the flame, which is usually in the form of a fabric around the flame.

**7.** The *luminosity* of flames depends on the manner in which the carbon is burned. Thus, when gas is burned in an open- or yellow-flame burner, light is emitted profusely; when it is burned in a Bunsen burner, the flame appears pale blue and almost destitute of light. In order to understand the cause of the great difference in luminosity in these cases, it is necessary to examine the structure of the flames and note the different conditions under which the carbon is burned. Hydrogen in burning, gives off an enormous amount of heat with very little light. It serves to produce light, however, by heating to incandescence the carbon that accompanies it, if any is present.

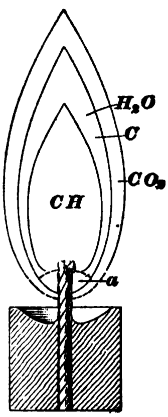



Fig. 1

**8.** The flame of a candle consists of four parts, as shown in Fig. 1. The lowest part *a* is of a bright blue color and emits very little light. The central part of the flame, marked *CH*, is composed of gas generated from the material of the candle by heat and is dark colored and transparent. It is surrounded by a shell or envelope of yellow luminous flame, which is marked *C* and $H_2O$. Outside of this is another layer, marked $CO_2$, which consists of hot gas and is almost invisible. The greater part of the oxygen, which moves from the surrounding atmosphere toward the interior of the flame, is intercepted in the outer layer of hot gas, and is united with the carbon that escapes outwards from the luminous layer, thus forming $CO_2$. The remainder of the oxygen passes inwards into the luminous layer of the flame, where it encounters the hot hydrocarbon gas that is passing outwards from the central space. As there is not sufficient oxygen to combine with both the hydrogen and the carbon, and as it combines with hydrogen more easily than with carbon, the hydrogen is taken from the compound and the carbon is left free and uncombined. The intense heat generated by the burning hydrogen raises the temperature of the free carbon so high that it becomes brilliantly incandescent. This is the only part of the process of combustion that generates

light of any consequence. This incandescence endures only while the carbon is passing from the central part of the flame to the outer layer—a very minute interval of time.

The luminosity of the flame is thus seen to depend on the momentary existence of the carbon in a state of entire freedom, at a high temperature, under circumstances that deprive it of oxygen. The moment that it receives enough oxygen, it passes into carbon dioxide and ceases to be luminous. Thus, the carbon is burned only in the outer, non-luminous part of the flame, and only hydrogen is burned in the luminous part.

**9.** When gas is mixed with air and is burned in an atmospheric burner, each particle of carbon is accompanied with enough oxygen to convert it into carbon dioxide, and the hydrogen is similarly provided for. They burn simultaneously, the hydrogen forming water, $H_2O$, and the carbon passing directly from the original hydrocarbon compound into a new combination, $CO_2$. It is not for a moment detached and maintained as free carbon, as in the candle flame; consequently, the opportunity to become incandescent and luminous never occurs. Therefore, the flame of an atmospheric, or Bunsen, burner emits very little light.

**10.** An open gas flame will lose much of its luminosity if its surface is made too large. When the pressure is too high, the gas is projected so far into the atmosphere that a considerable part of it finds enough oxygen to burn its carbon and hydrogen simultaneously, as in a Bunsen flame. That part of the gas which burns in this manner fails to emit light of any consequence.

A gas flame will smoke when the area of its outer surface is so small that it cannot take up oxygen from the atmosphere with sufficient rapidity to oxidize the carbon as fast as it arrives at the outer surface of the flame. Only a part of the carbon can then be oxidized; the remainder cools below the point of ignition and passes off into the air as suspended carbon or smoke. The trouble may be remedied by increasing the area of the flame, which is usually accomplished by increasing the pressure of the gas. An artificial draft, such as is made by a

chimney or a fan, will also cure the smokiness by increasing the supply of oxygen to the flame.

**11.** The intensity of the light emitted by a flame of any kind of gas depends on the area of the surface of the flame and on the temperature developed by the combustion. Thus, by comparing two burners that produce flames of different sizes while using the same pressure and volume of gas an hour, it will be found that the smaller flame will emit the more brilliant light. This result is due to the decrease of luminous surface from which light is radiated, which simply means a more rapid surface combustion per unit of area. By comparing two flames that are alike except in temperature, it will be found that the hotter flame will emit the larger volume of light.

By comparing the light produced by burning gases of different compositions, it is found that the greatest light is afforded by the gas that has the largest amount of carbon in proportion to its hydrogen. Thus, acetylene, which has twelve times as much carbon as hydrogen, by weight, gives about fifteen times as much light as an equal volume of average coal gas.

**12.** When gas is mixed with air before burning, the color and brilliancy of the flame undergo a great change. If common illuminating gas is used and the maximum proportion of air is supplied, the flame will be very small and pale, having a bluish top and a greenish center. But when the air supply is scant, the flame will burn with a dull yellow light and will tend to smoke. As long as the yellow flame can be seen, it is certain that the proportion of air is too small.

Other gases give characteristic colors when burned. When free carbon is burned to carbon monoxide, $CO$, the flame is of a bright blue color, and when carbon monoxide is burned to carbon dioxide, $CO_2$, the flame shows a characteristic pink or rose color; but when the carbon is burned to carbon dioxide directly, the flame is nearly colorless.

When gas was first introduced for lighting purposes, it was burned in the form of yellowish white flame in open burners. Later, better lighting results were obtained by mixing air with the gas, then burning it inside incandescent mantles.

### GAS BURNERS

**13.** All methods of producing light from gas or oils that are now in use depend on the incandescence of some substance that is exposed to the heat of the flame. In the open, yellow, or luminous flame the production of light is due to the incandescence of momentarily existing carbon particles furnished by the decomposition of the gas itself.

Among the gas-lighting burners utilizing open, yellow, or self-luminous flames may be mentioned *batswing*, *fish-tail*, *Argand*, and *regenerative* burners. The first tip used for illuminating gas was a plain orifice in a gas pipe, which produced less than 1 candlepower for each cubic foot of gas burned in an hour.

**14.** **The batswing burner,** shown in Fig. 2, consists of a slot in a convex tip that spreads the gas into a thin sheet of flame, shown at $B$, so that the air can combine with it readily. By reason of the higher temperatures obtained, the yield of light is much increased, as high as 2.5 candlepower being obtained from 1 cubic foot an hour with coal gas of 16 candlepower.

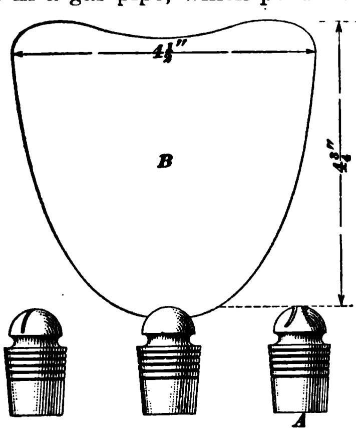


FIG. 2

**15.** The **fish-tail burner** is composed of two holes drilled in the tip at an angle in such a way as to spread the flame into a somewhat similar flame to that of the batswing. The batswing and fish-tail burners are still used in many places where light is seldom required and where incandescent burners could not receive proper care. They are so exceedingly wasteful of gas, however, that, for a given amount of light, they are more expensive to operate than the very poorest types of electric lamps, and there is seldom any excuse for using them.

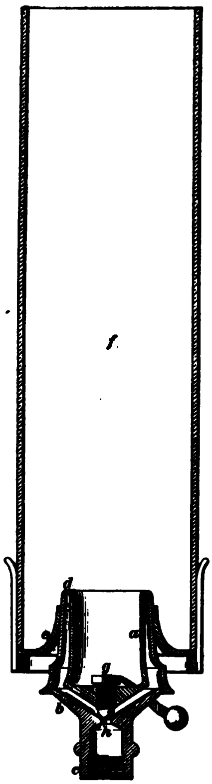



FIG. 3

**16.** The **Argand burner,** shown in Fig. 3, consists of a ring *a* attached by two hollow arms *b* to a socket *c* threaded to screw on to an ordinary burner nipple. The gas issues from the interior of the ring through a series of small holes *d* and the jets unite to form a complete circle of flame. The air is admitted to the flame through the perforation *e* and also through the central hole of the burner, thus supplying air to the inner and outer surfaces of the flame. The lamp, when used in connection with a glass chimney *f*, produces a little over 3 candlepower for each cubic foot an hour for 16-candlepower coal gas. The Argand burner is still used, although not universally, as the official standard for measuring the candlepower of gases; but, like the regenerative burner, it is not in commercial use, having been replaced by incandescent gas lamps.

**17.** The **regenerative burner** is simply an Argand burner in which the products of combustion are used to preheat both the air and the gas before burning. It produces from 7 to 10 candlepower from 1 cubic foot an hour of 16-candlepower gas.

## INCANDESCENT GAS LAMPS

### MANTLES AND BURNERS

**18.** In the incandescent gas lamp, the light is produced by subjecting oxides of the earthy metals thoria and ceria to the high temperature of a Bunsen burner. These oxides, when heated to incandescence, emit far more light than carbon, and after its introduction the incandescent gas lamp rapidly became the most important means of gas lighting.

**19. Gas Mantles.**—To utilize the higher temperature of the non-luminous Bunsen flame, it is necessary to provide an external permanent substance that will become luminous at high temperature. In 1885, when experimenting on the spectra of the rare earths, Dr. Carl Auer, and later Baron von Welsbach, wished to produce threads of those earths that might be heated to incandescence for spectroscopic analysis. For this purpose he saturated cotton threads with solutions of salts of these earths and burned out the vegetable matter, leaving the ash in the form of a thread. As these threads possessed considerable tenacity, he conceived the idea of knitting "stockings" of cotton, saturating them with solutions of rare earth salts, burning out the cotton, and placing the resulting mantle in a Bunsen flame for the commercial production of light. His first experiments were with erbium, which gave a feeble greenish light; later zirconium and lanthanum were tried, but were unsatisfactory.

After experiments with practically every known substance suitable for employment as an incandescent body, Welsbach discovered that a mixture of thorium and cerium gave a higher efficiency, better color, and greater strength than any other elements, and from these all modern gas mantles are made.

**20.** The fragility of the early mantles was the greatest obstacle to their use. They became useless after burning for 50 or 60 hours, and it was necessary to devise elaborate and expensive processes of manipulation before a commercially satisfactory product was obtained. It was found that the character of the fabric used had much to do with the strength of the mantle, and cotton, which was first used, has been superseded in all but the cheapest mantles by other fabrics, the latest and most satisfactory being an artificial fiber manufactured chemically. Mantles made from this fabric have burned without deterioration for 6,000 hours; a life of 2,000 hours is a conservative average for the best grade of modern mantles.

**21.** In manufacturing incandescent gas mantles, the fabric is purified by several washings in chemicals and distilled water and knitted into tubes cut into lengths, dipped in thoria and

ceria solutions, dried, and formed into mantles. The fabric is then burned out, leaving the ash of thoria and ceria, which is hardened under the blowpipe by skilled operators. The mantle is then dipped in collodion, which, on drying, forms a protective shell that enables the ash to withstand handling in shipment. This collodion is the substance that is burned off before the mantle is placed in service. The mantle is then mounted on a ring or cap and packed.

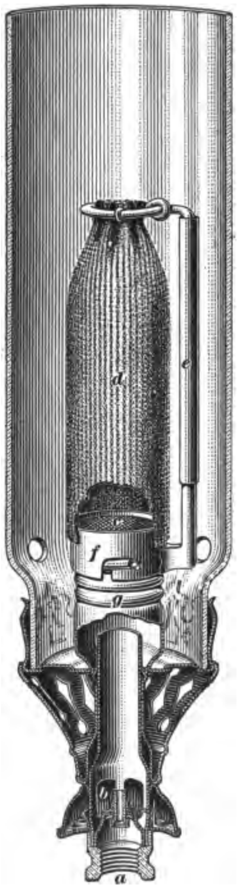



Fig. 4

Incandescent gas mantles of the best grade give an average candlepower in all directions of from 20 to 25 for each cubic foot of gas consumed hourly.

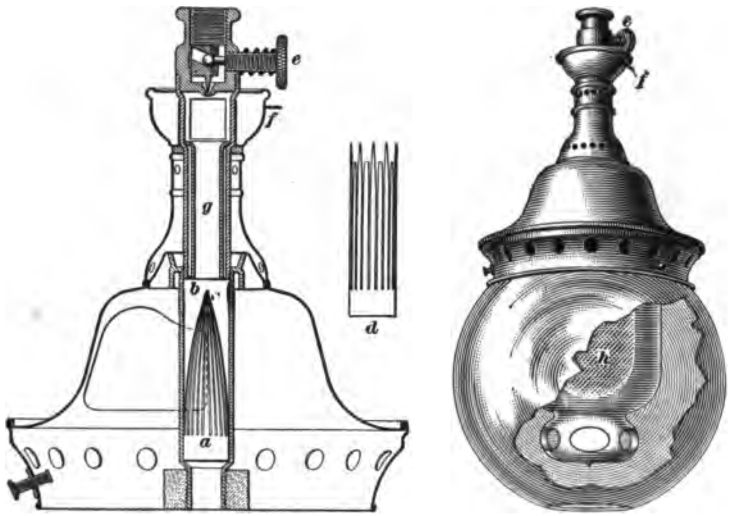
**22.** The **incandescent gas burner** is simply a Bunsen burner especially designed for use with a mantle. There are two types in common use, the *upright burner* and the *inverted burner*.

The **upright burner** is shown in Fig. 4; the gas enters at *a* and the air at *b*. The mixture burns on top of the wire gauze *c*, producing great heat but little light. This heat is transformed into light by heating the mantle *d* suspended over the flame to a high state of incandescence. The mantle is held firmly in position by the wire support *e* and the collar or ring *f*, which fits tightly around the tube *g*.

**23.** The principal difference in the construction of the two burners is that the **inverted burner**, shown in Fig. 5 (*a*) and (*b*), is provided with a thermostat *a* to compensate for the effect of the heat on the gases in the mixing chamber *b*. When these gases are cold, the thermostat is closed, as shown at *c*; as the gases become heated, it opens as at *d*, allowing a larger volume of the gas and air to pass

through to the burners. An adjusting screw *e* and an air-shutter lever *f* are provided for properly adjusting the supply of gas and air to the burners. A raceway *g* conducts the gas and air to the mixing chamber. An inverted mantle enclosed in a glass globe is shown at *h* in (*b*).

**24.** For the satisfactory operation of incandescent gas lamps, it is essential that the proper quantity of air-and-gas mixture be delivered to the mantle and that air and gas be in




(a) (b)

FIG. 5

proper proportions. In order that the same lamp may be used on different pressures, a gas adjustment must be provided which may be set for the particular gas pressure prevailing at the outlet.

The air adjustment is necessary in order to reduce the quantity of air when it becomes large enough to produce roaring. Ordinarily, satisfactory results may be secured with the air shutter wide open. The efficiency and satisfactory operation of the burner depend largely on the proper proportioning of the orifice, raceway, and mixing chamber.

**25.** Both upright and inverted burners are made in a variety of sizes. The upright burners come in sizes consuming from 2 to 6 cubic feet of gas an hour, and when equipped with a good mantle produce an average of 20 candlepower in all directions for each cubic foot of gas consumed hourly.

Inverted burners are made in sizes consuming from 2 to 12 cubic feet an hour, producing an average of 25 candlepower in all directions for each cubic foot of gas consumed hourly.

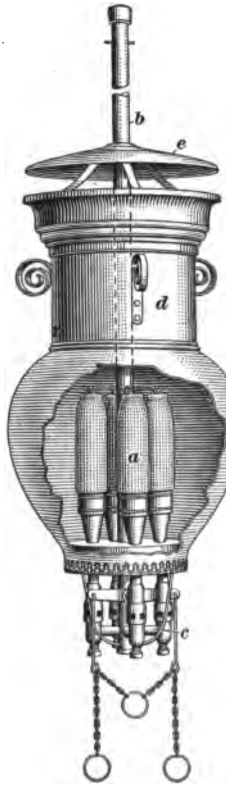


FIG. 6

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**GAS ARCS**

**26.** Incandescent gas lamps containing more than one mantle are called gas arcs, and are made upright and inverted. In some cases they are simply clusters of several burners with an orifice and gas adjustment for each mantle. In other cases, but one orifice and gas adjustment is used, the several mantles being fed with gas from a common mixing chamber. The gas arc is simply a modification of the single-mantle unit from which it differs in neither efficiency nor operation.

Fig. 6 shows an upright, gas, arc lamp used for indoor service. It consists essentially of a cluster of incandescent burners *a* supplied with gas through a tube *b* suspended from the ceiling. The tube *b* is screwed into a distributing socket that feeds the arms *c* to which the burners are attached. The air and gas checks are located at the base of each burner. The air supply to the globe is obtained through the gallery and lower neck of the globe; the products of combustion escape to the atmosphere through the top of a metal chimney *d*; a shield *e* on the tube *b* diffuses the current of hot air and reduces its temperature before it reaches the ceiling.

**27.** Fig. 7 (*a*) shows an inverted arc lamp for indoor lighting; the interior construction of the same lamp is shown in view (*b*). This lamp is for lighting large areas and has a maximum wide light distribution; for this reason it is a superior lamp for lighting stores, auditoriums, etc. The gas enters the lamp through the feedpipe *a* and passes to the Bunsen tube *b*, where it mixes with the air in the proper proportion before entering the burners *c*. The supply of gas is regulated by the

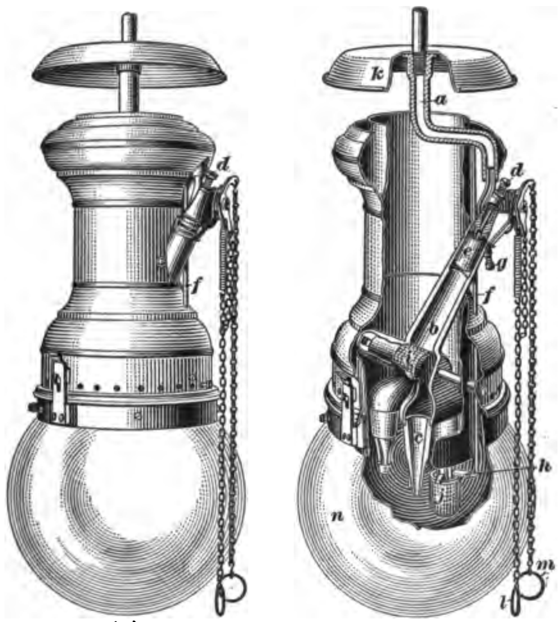



FIG. 7

screw *d* and the supply of air by the shutter *e*. A pilot tube for lighting the burner is shown at *f*; the small screw *g* adjusts the flow of gas to the pilot tip *h*, and the gauze cartridge *i* prevents the flame from flashing back into the chamber *b*. An inverted mantle is shown attached to the burner at *j*. A deflector or baffle *k* protects the ceiling from the heat.

To light the lamps it is only necessary to pull down on the chain *l*; to extinguish the light, the chain *m* is pulled. The

globe *n* is made to swing down in hinged holders, giving easy access to the mantles for cleaning purposes.

**28.** Gas arcs are made in both indoor and outdoor types, which differ only in the means taken to protect the burner from drafts. In size they range from three to five mantles, producing the same amount of light as clusters of from three to five single burners, respectively. It is not practicable, however, to equip the gas arcs with adequate shades or reflectors for controlling the direction of the light, and as illuminators they are considerably less efficient

FIG. 8

FIG. 9

than single-mantle units fitted with suitable reflectors, consuming the same amount of gas. Gas arcs are now being replaced by single-mantle units of high candlepower. Both the gas

consumption and candlepower of any gas lamp depend to a great extent on the quality of gas supplied to it and on the freedom of the gas passage from dirt, etc.

**29. Types of Single-Mantle Lamps.**—Fig. 8 shows a large, single-mantle, inverted, incandescent, gas lamp suitable for lighting stores, auditoriums. halls, etc. The same burner is shown in Fig. 9 in an ornamental housing. The lamp consumes about 100 cubic feet of gas an hour and has about the same illuminating power as the three-mantle, inverted, arc lamp.

In Fig. 10 is shown the same lamp used in connection with a semi-indirect fixture in which about two-thirds of the light is reflected toward the ceiling and from the ceiling is diffused into the room; one-third of the light comes through the globe.

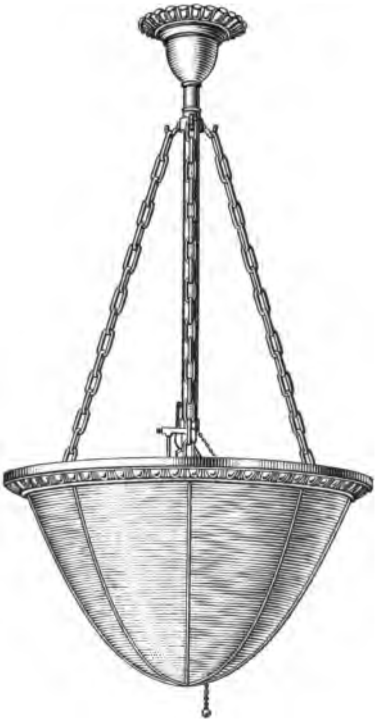


FIG. 10

Fig. 11 illustrates a small upright burner enclosed in a globe. This burner consumes from 1.6 to 2 cubic feet of gas an hour, and is especially desirable for replacing upright open-flame tips on existing fixtures. The burner contains a by-pass providing for a continuous burning pilot light, so that the light may be turned on or off by the key shown in the illustration.

In Fig. 12 is shown a stiff bracket equipped with an upright burner; this lamp consumes about 1.6 cubic feet of gas an hour. Fig. 13 shows another form of bracket equipped with an inverted burner and mantle, which consumes about 4 cubic feet of gas

an hour. The lamps shown in Fig. 12 and Fig. 13 are suitable for lighting bedrooms, bathrooms, and other rooms where side lights are desirable.

**30.** Fig. 14 shows a fixture carrying a cluster of inverted

FIG. 11

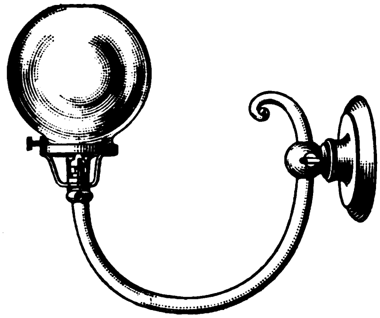


FIG. 12

lamps, each of which consumes about 4 cubic feet of gas an hour. All the lamps are controlled by a single gas-cock to which is attached a chain pull. The ignition is by a pilot light.

FIG. 13

Fig. 15 shows an indirect lighting fixture in which all of the light is reflected to the ceiling and from that point is diffused into the room. The burners are provided with a pilot light and the gas is controlled by a central gas-cock which is operated by a chain pull. The lamps are upright incandescent burners consuming about $5\frac{1}{2}$ cubic feet of gas an hour. In this form of gas fixture any number of lamps may be used, to meet the existing conditions.

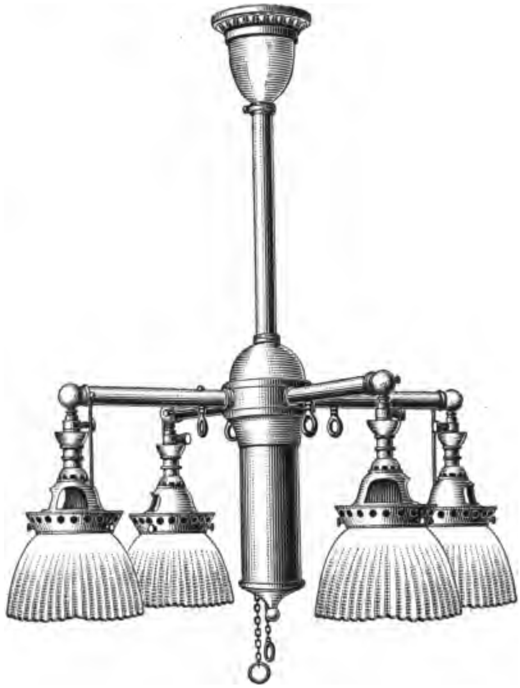


Fig. 14

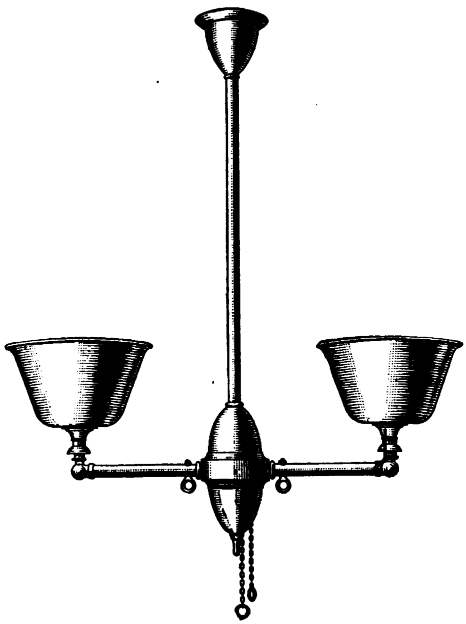




Fig. 15

### IGNITION SYSTEMS

**31.** Incandescent gas lamps are usually lighted by means of a pilot flame, which burns continuously and lights the gas when it is turned on. Pilot lights for single-mantle units consume from $\frac{1}{12}$ to $\frac{1}{8}$ cubic foot of gas an hour, and those for gas arc lamps consume $\frac{1}{4}$ cubic foot. A pilot flame gives only enough light to see the lamp in the dark.

FIG. 16

**32.** A self-lighting gas burner is shown in Fig. 16. The key is so made that the gas can never be entirely shut off, and when it is turned to extinguish the light, enough gas is allowed to pass to maintain a very small flame at the tip of the burner.

There are two general types of yellow pilot lights: one is fed by a small pipe extending up from the by-pass through the Bunsen tube and into the space within the mantle; the other is fed by a small tube *a*, Fig. 16, led up from the by-pass cock outside of the burner to a point near the mantle. A small yellow flame burns at the top of this tube constantly and immediately ignites the gas when the by-pass cock is opened. The glass globe *b* protects the pilot light from drafts.

**33. Magnet Valves.**—When lamps are placed in positions where they are not readily accessible, they may be lighted from a distant point by means of **magnet valves**, one form of which is shown in Fig. 17 (*a*). The valve *a* is operated by a set of dry-cell batteries *c*, which are connected by the wire circuit *d* and controlled by push buttons on the board *e*. The valve *a* is equipped with two magnets *f* and *f'*. The tube *g* supplies the pilot light, which should be kept burning continuously. The burner is lighted by pressing the button *h*; this allows the current to pass through the magnet *f* and lift the lever *i* against the valve lever *j*, thus opening the valve and allowing gas to

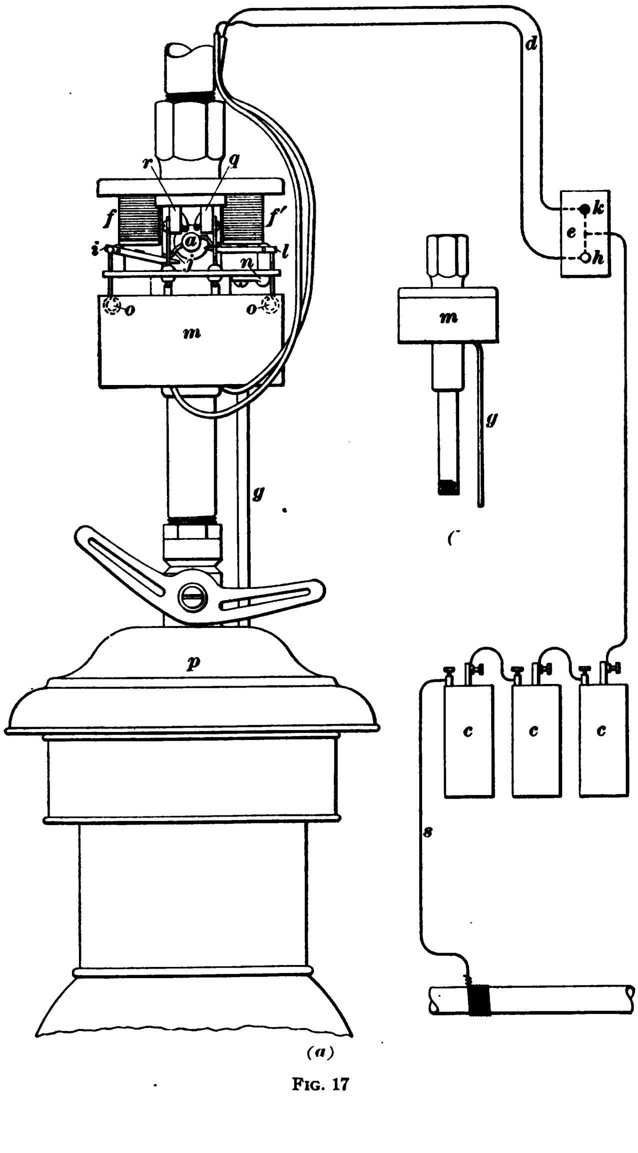
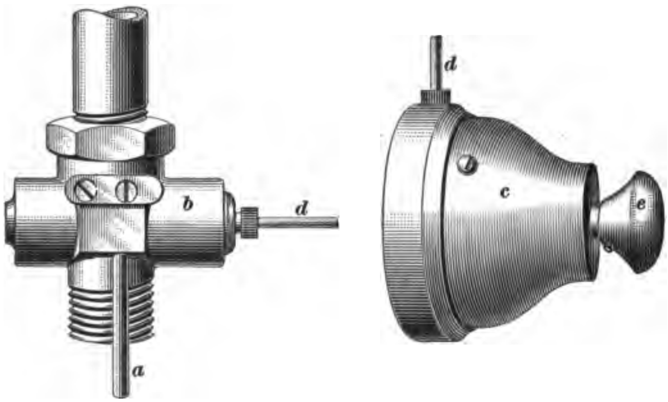



FIG. 17

pass to the burners, where it is ignited by the pilot light. The light is extinguished by pressing the button *k*; the current then passes through the magnet *f′*, lifts the arm *l*, and shuts off the gas. The valve and magnets are enclosed in a casing *m*, which is shown in the illustration lowered out of place to give a view of the mechanism. The casing is held in place by a catch *n*. The general appearance of the valve when the shell is in place is shown in (*b*).

The valve can be operated also by hand instead of by batteries by attaching light chains to the rings *o*.

The valve should be connected to the lamp at least 5 inches above the baffle *p* in order to protect it from the heat. If the




(*a*) (*b*)

FIG. 18

lamp is placed out of doors, a fireproof and waterproof wiring of not less than 20 B. & S. gauge should be used. If the lamp is located inside a building, ordinary office wiring can be used. In wiring, connect the black button *k* to the binding post *q* and the button *h* to the post *r*. The wire *s* leading from the side of the batteries should be grounded by connecting it to the gas pipe as shown. The surface of the pipe should be scraped bright and clean before the wire is attached to it.

**34. Pneumatic Valves.**—The pneumatic valve, shown in Fig. 18, is another device for opening and closing the gas valve

of a lamp from a distance. It consists essentially of a pump for compressing air, a tube for conveying the compressed air, and a valve. The valve is shown in (*a*) and the pump in (*b*). The tube *a* feeds the pilot light. The gas-cock *b* and the pump *c* are connected by the tube *d*, which has an outside diameter of $\frac{3}{25}$ inch. The lamp is lighted by pulling out the plunger *e* and extinguished by pushing it in.

**35. Spark Ignition.**—Where lamps are infequently used and the expense of a continuously burning pilot flame would be excessive, electric-spark ignition is both satisfactory and reliable. An electric spark is caused to flash through the stream of gas issuing from the burner when the gas is turned on, thus igniting it.

**36. Filament Ignition.**—Recently a system of ignition has been devised in which a small dry battery, concealed in the fixture, lights the gas by heating a small wire filament, shown at *a*, Fig. 19. The igniter *b* is fastened to the top of the lamp, as illustrated. Fig. 20 shows the fixture with two lamps or inverted burners complete. The battery *c* is encased in a removable casing, or holder, which fits into the fixture at *d*. A pull on the chain *e* turns on the gas and at the same time makes an electric connection between the filament igniter *a* and the battery *c* located in the center of the fixture. The electric current heats the filament *a* in the igniter *b* to a red glow, when the gas rises and surrounds the filament *a*, as shown by the arrows in Fig. 19. Catalytic action between the gas and the hot wire instantly raises the temperature of the filament to the point of ignition and quickly lights the gas rising from the burner.

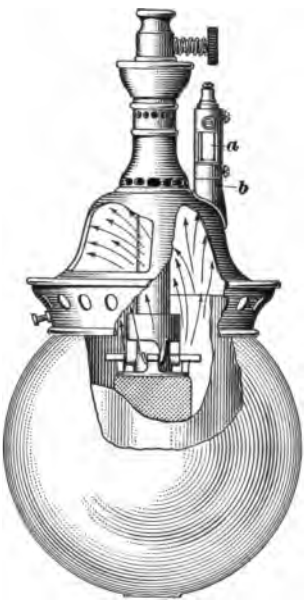


FIG. 19

### INSTALLATION AND ADJUSTMENT OF INCANDESCENT GAS LAMPS

**37.** Incandescent gas burners require practically constant gas pressure at the burner, and a supply of gas of uniform quality. Nearly all the troubles arising in the operation of these lamps are due to improper adjustment or to varying gas pressure and quality, the latter being a more frequent cause than the former. Varying pressures may be due either to

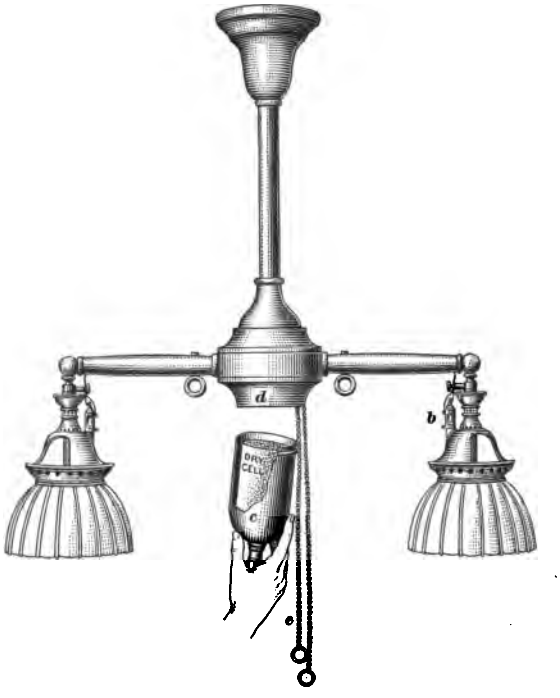



Fig. 20

insufficient capacity in the house piping or to pressure variations in the street mains. In the former case pipes of the proper sizes should be installed; in the latter case, a governor may be installed at small expense. Low-pressure governors should always be adjusted for the highest pressure at which they can continuously deliver gas, which will be slightly below the lowest

pressure occurring on the street main at any time. The gas pressure for incandescent gas lamps should not be less than 2 inches of water column at the burner, and a higher pressure is preferable.

Governors are necessary only when the variations in pressure are sufficient to produce carbonization of mantles, or a noticeable fluctuation in the light-giving power of the mantles. Variation in gas quality can be corrected only at the gas works.

**38.** Incandescent gas lamps are provided with adjustable gas checks, which make it possible, with slight changes of equipment, to adjust any burner for any pressure between 2 and 8 inches.

The adjustment of upright burners differs from that of inverted burners in that the former are not usually provided with air shutters. To adjust upright burners, turn on the gas and light the mantle with the gas adjustment nearly closed. Open the gas-adjustment screw gradually until further opening produces no increase in the amount of light given out, then gradually close the screw until the light just begins to diminish. At this point the mantle should be fully incandescent over the entire surface and no flame should be visible above the mantle.

**39.** To adjust inverted lamps, open the air shutter wide and proceed as before, observing that at the final adjustment there is no dark or brown spot in the bottom of the mantle. If an objectionable noise occurs at this point, close the air shutter until the noise nearly ceases; or, if necessary to eliminate noise entirely, slightly under adjust the lamp, gradually closing the air shutter until the noise disappears and the mantle is fully incandescent throughout. At this point the mantle will give off a bright white light, and the gas will be entirely consumed within the mantle.

Pilot lights should be adjusted to give the smallest flame that can be permanently maintained at the lowest pressure received during the day. Pilot flames sometimes require a slight increase in adjustment every few months, on account of the fouling of the tube or tip.

## TROUBLES AND REMEDIES

**40.** It is to the interest of the consumer that all the lighting and heating burners on his premises be thoroughly inspected and put in good order at least once every year. When the inspection is made annually, it requires but little time, and the cost is small compared with the saving that will usually be made in the gas bill.

**41. Insufficient Air Pressure.**—When the gas-fitter is requested to inspect the gas-lighting apparatus in a dwelling or other premises and to put in good order everything that appears to require improvement, with the object of reducing the consumer's gas bills, he should first ascertain whether the various burners are supplied with gas at a sufficient pressure. For this purpose all the burners that are ever in use at the same time, including all cooking and heating burners, should be lighted. The appearance of the flames will show whether the supply pipes are large enough; if still in doubt, the water gauge should be applied.

If the pressure appears to be too low, it may be due to the pressure reducer or governor at the meter being improperly adjusted. Sometimes these governors become fouled, causing considerable resistance to the passage of gas. By opening the governor valve to its full width, or by removing the governor temporarily, it can be quickly ascertained whether the lack of pressure is due to the smallness of the pipes or to the resistance of the governor.

Sometimes the trouble is due to a defective meter. The condition of the meter can be judged by applying two water gauges—one at each side of it. Then, if the gauge on the house side of the meter shows a much smaller gas pressure than the gauge on the service side, the meter is defective and should be replaced or repaired.

If there is no governor on the system, the pipes leading to the stoves should be supplied with one. Each burner and air shutter should be so adjusted that the proportions of air and gas are at all times the highest that can be used without snapping back.

**42. Open-Flame Burners.**—Attention should be given to the condition of the open-flame burners. The flames should be as large as practicable and perfectly steady, without flickering or hissing. The outline of the flame should be smooth and free from wavering tongues or deep notches. The color should be as nearly white as practicable. If the flame is yellow or dull, suggesting smokiness, it shows that it is not spread out sufficiently; the tip should then be replaced with a new one having a thinner slit.

**43.** The smoking of open gas flames, as given by union-jet and batswing burners, may be due to defects in the burner or to excessively rich gas. Smoke is produced when the supply of air is too small to burn the carbon in the gas.

If the tip fails to spread the flame sufficiently to secure the necessary oxygen for good combustion, the burner will smoke. The defect may be in the tip, or it may be that the pressure is reduced too much by a check in the interior of the burner. The proper remedy is to provide a new tip having a thin, clean slot, and if that does not properly spread the flame, the check should be readjusted or removed so as to increase the pressure.

If the gas smokes because it is extra rich, the trouble may sometimes be remedied by providing the burner with a glass globe, by using a burner having a chimney, or by using incandescent burners.

**44. Wasteful Methods.**—The question of illumination should also receive attention. Frequently several small burners are used to light a room, when one or two large burners would give more light with a smaller consumption of gas.

Gaslights that are used only a few minutes at a time and are turned down during the intervals, as in bathrooms, water closets, cellar stairways, etc., are usually very wasteful of gas, and a saving can be made by employing self-lighting burners in all such places.

The gas-fitter should advise the removal of all open-flame burners and the adoption instead of incandescent burners with good mantles, except in places where the mantles are liable to receive rough usage. Some persons, however, are prejudiced

against mantle burners on account of the apparently greenish color of the light, and also because a breaking of the mantle leaves them without light until the mantle is replaced. In the latter case it is advisable to recommend replacing one-half of the open-flame burners in the living rooms with mantle burners, keeping the open-flame burners in reserve, to be used in case of breakage of mantles.

**45.** Many persons waste gas by turning on too much of it, in cases where the gas is delivered at a high pressure. This is shown by Table I, which gives the results of experiments

**TABLE I**

**CANDLEPOWER OF 4-FOOT OPEN-FLAME BURNER AT DIFFERENT PRESSURES**

| Gas Pressure Inches of Water Column | Gas Consumed in 1 Hour Cubic Feet | Light Emitted by Each Cubic Foot Candlepower | Candlepower of Flame |
|---|---|---|---|
| .5 | 3.90 | 3.00 | 11.70 |
| 1.0 | 5.60 | 2.40 | 13.40 |
| 1.5 | 7.00 | 1.90 | 13.30 |
| 2.0 | 8.45 | 1.50 | 12.67 |
| 2.5 | 9.60 | 1.35 | 12.96 |
| 3.0 | 10.50 | 1.11 | 11.65 |

conducted with a 4-foot open-flame burner. With the burner tested, the highest efficiency was obtained with .5-inch pressure; experience has shown that this pressure proves satisfactory for other burners. If the gas pressure in the pipes is higher than this, the pressure at the burner must be reduced either by a governor or by closing the gas-cock until the desired pressure is obtained.

The correct pressure for a gas burner can be determined quite closely by the shape of the flame. When the pressure is too high, the flame will flare, show a ragged edge, as illustrated in Fig. 21 (*a*), and make a hissing noise; the key in the gas fixture should then be turned slowly to check the gas

pressure until the flaring disappears. When the gas pressure has been properly checked, the flame will be silent, bright, and steady, assuming the form shown in (*b*). When the flame thus appears, the greatest amount of light is obtained for the least gas consumption; that is, the burner is then burning the gas at the point of maximum efficiency.

**46. Adjustment of Incandescent Burners.**—The proper performance of an incandescent gas lamp, assuming the mantle to be of proper size and good quality, depends on the delivery of the correct quantity of air-and-gas mixture of proper proportions. An insufficient quantity of mixture will fail to fill the mantle, which will not become incandescent throughout.

FIG. 21

The delivery of an insufficient quantity of mixture may be due to a lower gas pressure than is sufficient to overcome the resistance of the passages, or the passages themselves may be obstructed. In the former case, any gauzes or similar obstructing equipment should be replaced by changing to gauzes of wider mesh, etc., or removed entirely, if necessary.

Passages containing gauzes or similar equipment should be blown out about once a month to remove obstructing deposits of dirt. If the mixture lacks the proper proportion of air, the carbon will not be entirely consumed, and the unconsumed part will be deposited in the mantle. Lack of sufficient air in the mixture may be due to the fouling of the gas orifice, by which

the velocity of the jet is so reduced that it lacks the necessary air-entraining power; or the gauzes or similar equipment in the mixing chamber may interpose such resistance to the flow of the mixture that enough back pressure exists to prevent the ingress of sufficient air through the air parts. In either case, the same procedure as recommended in case the mantle fails to fill properly should be followed. In upright mantles, carbonization is almost always an indication of dirty gauzes.

FIG. 22

When too much air is entrained by the gas, a roaring or hissing noise will be produced, and the lamp will show a tendency to light back to the orifice, or flash back. In this case the air shutter should be closed until the objectionable noise is removed, or more obstruction interposed to the flow of mixture, as by the use of a gauze of finer mesh.

**47.** Where the ceilings are low and consequently near the burner, they may become discolored, although not actually scorched. Each gas flame causes an upward current of hot air, which ascends until it reaches the ceiling. This movement produces a circulation of the air within the room, and particles of dust in the current will be carried to the ceiling at a point directly over the burner; consequently, that part of the ceiling soon becomes discolored by the adherent dust. The discoloration is usually charged to smoke from the gas, but it is mostly due to the stream of dust. If the gas does actually give off smoke, it will aggravate the trouble; but that can be easily remedied by providing a proper burner.

The trouble will be mitigated, although not wholly cured, by hanging an ordinary smoke bell over the flame. By spreading out the current, its velocity is checked, the amount of dust that strikes the ceiling within a given area is reduced, and the discoloration is lessened. The only effectual method of preventing this discoloration of walls and ceilings is to intercept the current of hot air arising from each burner, and to conduct it to a chimney or ventilating flue by means of a hood, or a ventilating crown, shown in Fig. 22, suspended at the ceiling over each flame or set of flames. The crown is made with and without the ventilating openings *b*. When used with these openings and connected to a ventilating duct, not only is the discoloration of the ceiling prevented, but the upward current of air created by the heat of the gas removes the products of combustion and also aids ventilation by carrying along a considerable amount of air. The shield, when discolored, can be cleaned with a damp cloth.

## GAS FIXTURES

### GENERAL CONSTRUCTION

**48. Nomenclature and Classification.**—The term **fixture** is applied to the apparatus that supports the gas burners and serves to connect them to the supply pipes. Fixtures divide into three general classes: *brackets*, or *side lights*, which project from the walls; *pendants*, or *chandeliers*, which hang from the ceiling; and *pillar lights*, which stand on a base, such as a table or a newel post. The latter are now seldom used. Brackets made without joints are called *stiff brackets*, and those having flexible joints are called *swing brackets*.

All fixtures that hang from the ceiling may properly be called pendants; but, as commonly applied, this name is restricted to fixtures of plain construction carrying one or two lights. If the number of lights is greater, or the construction is decidedly ornamental, the term chandelier is used. This name is applied to the fixture without regard to the variety of lights that it

carries, whether candles, kerosene lamps, gas burners, or electric lamps. The terms *gasolier* and *electrolier* have been devised to distinguish a chandelier bearing gaslights from one carrying electric lamps, but these terms have not come into general use.

Ornamental fixtures are usually built over a frame or skeleton of plain brass or iron tubing. The ornamental part consists of thin tubes, or shells, of brass, which are slipped over the main tubing and are bound in place by screwing the various fittings tightly together.

**49. Gas-Cock.**—The most important part of any fixture is the *key*, or *cock*, by which the gas is turned on or off. The safety of the inmates of the rooms from poisoning or suffocation, or from injury by explosions of gas, requires that the key of every fixture be properly constructed and adjusted. A key loose in its socket is very liable to be opened accidentally, or to be reopened unintentionally when the fingers are removed after closing it. A loose key is so dangerous that it should not be permitted to remain thus under any circumstances.

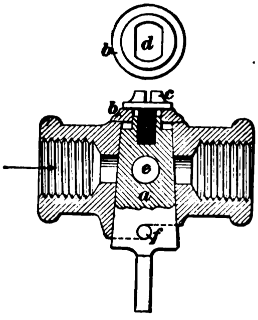


FIG. 23

The proper construction of a key is shown in Fig. 23. The plug *a* should be tapered and ground into its seat until it has a perfect bearing throughout the whole length of the socket. It should be held in place by means of a washer *b* and a screw *c*. The washer should have a central hole, as *d*, with one or two straight sides, and it should fit over the flat-sided end of the plug without looseness or play, so that when the plug turns the washer will turn with it. Any play at this point will tend to loosen the screw *c* and thus spoil the tightness of the key. It is a very common mistake to make the dimensions of the washer and screw too small, causing the washer to wear loose quickly when the screw is properly tightened up. The head of the screw should always be made large enough to afford a good hold for a screwdriver. Keys having small thin washers, or screws with small shallow slots, should be rejected. There

should always be some clearance under the washer and under the screw head, so that when the screw is tightened up they will never come to a bearing on the end of the plug.

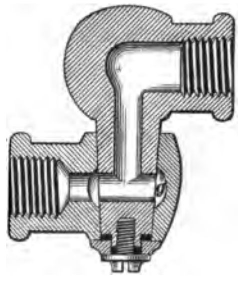


FIG. 24

**50.** An important detail of a key is the stop-pin *f*. This pin projects from the side of the plug and engages shoulders cut on the body of the socket, thus limiting the motion of the plug to one-half turn, always stopping the plug when the key is fully closed. This pin should be strongly made, so that it cannot be broken easily. A key that has no stop-pin is dangerous, since it is quite likely to be left partly open when it is believed to be closed. Such a key, when discovered, should immediately be repaired or replaced. The plug should be lubricated with mutton tallow, the excess of tallow being carefully removed from the passages for gas.

The diameter of the hole *e*, Fig. 23, should never exceed one-third the diameter of the plug at that point. If the hole is made larger, the bearing surfaces are so reduced that the key is likely to become leaky in a short time.

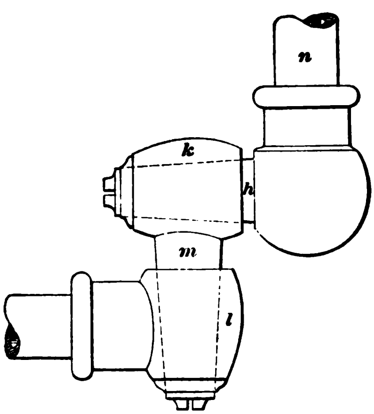



FIG. 25

**51. Joints.**—The construction of *swivel-joints* is shown in Figs. 24 and 25. The mode of securing the plugs in the sockets is the same as in Fig. 23. Each socket is provided with a groove *g*, which permits the gas to pass freely into the bore of the plug, in all positions. Fig. 24 shows an ordinary *single swivel-joint*, and Fig. 25 shows the arrangement of a *double swivel-joint* or *universal joint*. The plug *h*, Fig. 25, turns in a socket *k*, formed in the head of the plug *m*, which

revolves in the socket *l*. The pipe *n* can thus swing around the axis of either plug, or both, at the same time.

This construction is not suitable for an apparatus that requires a large supply of gas, because the dimensions become so great as to be clumsy. When the full capacity of the pipe is required to carry the desired amount of gas, the swivels may be constructed substantially as shown in Fig. 26; this is called a *full-bore swivel*. The sections *a* and *b* are fitted together with a conical joint *c*, which permits complete rotation. The joint is tightened by means of the bolt *d* and nut *e*, and if it becomes leaky at any time, it can be readily reground. The passageway for gas is equal to the full area of the pipe at all points; therefore, it offers very little obstruction to the flow.

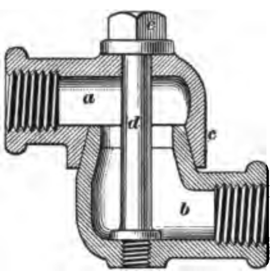



FIG. 26

**52.** Fig. 27 shows the construction of a *ball joint*, which permits the tube to swing to a limited extent in any direction, and also to turn on its own axis. The tube *a* is the drop piece extending through the ceiling. The tube *b* is attached to a ball *c* that is confined in a socket *d* by means of a screw-cap *e*. No packing material is employed to make the connection gas-tight, as the surfaces are accurately ground. The swing of the tube is limited by the size of the hole in the cap *e*. This class of joint is sometimes used at the top of swinging chandeliers.

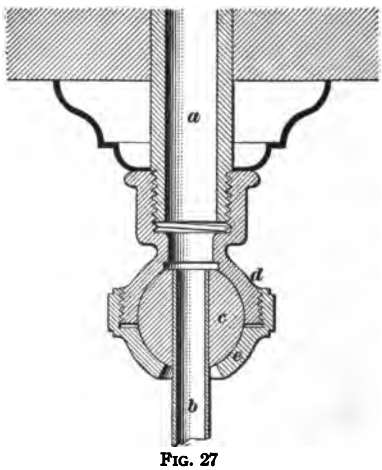



FIG. 27

**53. Portable-Lamp Connections.**—For rooms where portable gas lamps are needed for reading, sewing, piano, or decorative lighting, and for other portable gas appliances

requiring the use of flexible tubing, a neat and substantial method of connecting the flexible hose to the gas pipe is shown in Fig. 28 (*a*); view (*b*) shows the baseboard partly cut away

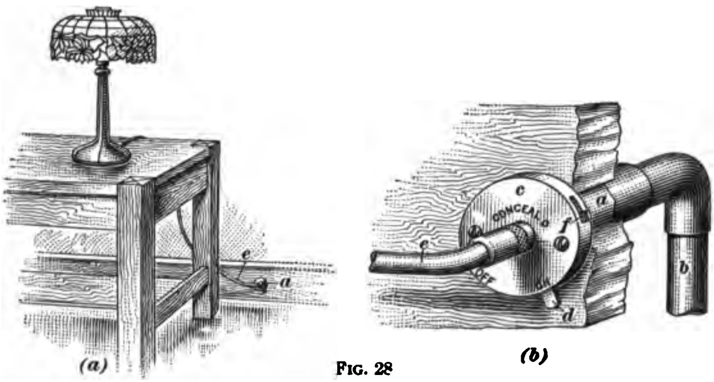



FIG. 28

to show the manner of connecting the valve *a* to the gas pipe *b*. A thin plate *c* sets closely against the baseboard; the valve *a* is operated by the switch lever *d*. To turn the gas on, the lever is moved to the station marked *on;* to turn the gas off, the lever is shifted to the station marked *off*. At these stations the lever is held firmly in position by springing into a slot or notch cut in the plate *c*. The hose *e* is kept in position by a lever at *f*. The valve can be placed in the wall, behind the baseboard, or under the floor, as desired. The gas pipe *b* should also be provided with a shut-off valve located in the cellar or in some place convenient for closing off the gas for repairs.

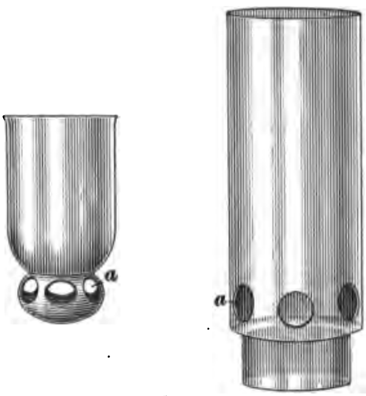


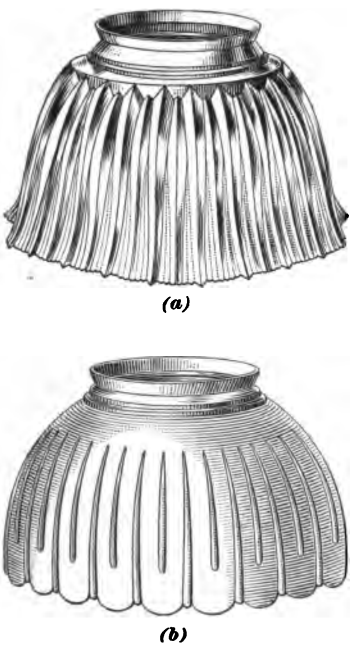

FIG. 29

**54. Glassware.**—Chimneys and cylinders are usually of clear glass, often having a portion of the surface frosted to shield the eyes from the glare of the bare mantle. The purpose of the chimney used with upright mantles is to protect

the mantle from drafts and to increase the supply of air to the outside of the mantle. The cylinder used with inverted mantles serves a similar purpose.

In places where glass chimneys and cylinders would be liable to frequent breakage, mica chimneys and cylinders are used. These, however, blacken more or less rapidly, and should not be used where glass will serve.

The best chimneys and cylinders are provided with air holes *a*, Fig. 29. Two forms of mantle chimneys are shown in the illustration; the one on the left is for an inverted mantle; the one on the right is for an upright mantle. These forms of chimneys increase to a considerable extent the light produced by the mantle. The proper size and proportion of chimneys and cylinders, and the size, number, and location of air holes differ in different lamps, and those recommended by the manufacturer should always be used.



(*a*)

(*b*)

Fig. 30

**55. Shades and Reflectors.**—Shades are used to screen the eyes from the glare of the bare mantles, and reflectors are used to reflect the light to some point where it is required. Shades should be of such a form that the bare mantle cannot be seen from any ordinary position, should diffuse the light so that the shade itself does not appear too bright for comfort, and should be of attractive appearance.

Reflectors are made in various forms according to the manner in which the light is to be distributed. Some shades are designed also to serve as reflectors; but in residence lighting the appearance of the shade is of more importance than the direction of

the light, and decorative shades are much more popular than the more scientifically designed reflector shades. The latter are shown in Fig. 30 and are widely used for lighting store and office buildings. View (*a*) represents a prismatic glass reflector that directs the rays of light from the incandescent mantle in all directions; view (*b*) is a translucent shade, so constructed as to allow the passage of light so perfectly in every direction that its source cannot be clearly seen through the shade. The shades shown in Fig. 30 are used for inverted gas lamps.

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### LOCATING GAS FIXTURES

**56.** The chief considerations that govern the location of gas fixtures are: That they shall light the rooms to the best advantage and that they shall cause no danger from fire.

In bedrooms, lighting fixtures should be located so that the bed, wardrobe, dressing case, mirror, etc. may be placed in desirable positions without interfering with the light. The positions of the closets should be noted, and if practicable the light should be arranged to shine into them, so that the contents may be easily seen. Dressing mirrors should be provided with two stiff bracket lights, one at each side. They should be placed as high as they can conveniently be reached, in order to properly illuminate the head and shoulders of the person using the mirror.

In bathrooms, the lights should be set high, so that a person will not be liable to strike them in taking off or putting on clothing. A light should not be located over a bathtub or a wash bowl, because of the liability to accident.

A kitchen or laundry should be lighted by pendants whenever practicable. If side lights must be used, they should not be placed over the sink or near enough to it to be liable to be struck, or be splashed with water. A side light should not be placed over a set of tubs if it can be avoided.

A gas fixture should never be placed in a closet or other very small room, if there is any chance that the door may be closed and the light left burning. If that should happen, the temperature would rise rapidly, and there would be great danger

of setting fire to any combustible material that might be in the room.

**57.** Stairways should be provided with a light at the top, whether there is one at the bottom or not. A light on the newel post alone is not sufficient to properly illuminate the steps. People having defective sight are especially liable to accident on stairways, and the light should be arranged so as to avoid all shadows that might prove deceptive. The stairway leading from the kitchen to the basement or cellar should be lighted by a burner that is located some distance away from the foot of the stairs. If the light is near the foot of the stairs, it is very apt to be struck when large articles are carried past.

Hallways are best lighted by a pendant; if a side light is used, it should be placed where it will not interfere with the coat rack, mirror, or other hall furniture. A pendant in a hallway or vestibule should be set so high that the globes will not be liable to be knocked off by a person putting on an overcoat, etc.

**58.** Chandeliers should be hung from the center of the ceiling, as nearly as practicable. If several side lights are used in the same room, they should be placed at the same height. Swing brackets should not be used for lighting hallways, stairs, vestibules, or other passageways, because of the danger from fire. The light is very liable to be swung too close to the wall, and to be overlooked until the building is set on fire. Swing brackets are always a source of danger when they are located within reach of woodwork or drapery, and therefore are not to be recommended for general use. It is preferable, in most cases, to use instead two single lights on stiff brackets, or else a bracket having two or more rigid arms with fixed lights.

Care should be taken in locating side lights to make sure that wooden doors cannot be swung back against them. Lights should not be placed where they may be subjected to strong drafts of air, or the sudden slamming of a door. A gas burner when extinguished with a full head of gas on is very dangerous.

A light should never be placed over or near hot-air registers in the floor or wall, for the light will flicker incessantly and will be a great annoyance.

**59.** The proper height of gaslights above the floor depends somewhat on circumstances. In ordinary dwellings having a ceiling 9 feet high or more, side lights should be placed from $5\frac{1}{2}$ to 6 feet high. Pendant lamps should be hung as high as possible, consistent with ease of access. If the rooms are large and high, the lights of chandeliers may be placed at a height of from 8 to 9 feet, or even more if controlled by a magnet or a pneumatic valve. Side lights in hallways and vestibules of churches and similar buildings should be placed at a height of at least 7 feet. Low lights should be avoided, because they are tiresome to the eyes. If they must be used, they should be provided with dense shades.

## LIGHT

### PROPERTIES OF LIGHT

**60.** Light diminishes in intensity as it recedes from the luminous body, the law governing the diminution being: *the intensity varies inversely as the square of the distance from the source of light.* Thus, if the two equal surfaces $A$ and $B$, Fig. 31,

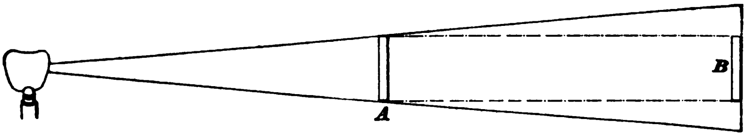


FIG. 31

are illuminated by the same lamp, which is 2 feet away from $A$ and 4 feet from $B$, then $B$ will receive less light than $A$, in inverse proportion to the squares of their relative distances, or in the proportion of $\frac{2^2}{4^2}=\frac{4}{16}=\frac{1}{4}$.

That this law must be true is evident from an inspection of the figure. The light that is intercepted by $A$, if permitted to proceed, will illuminate an area at $B$ that is twice as high and twice as wide as $A$. The same amount of light is thus

spread over four times the area of surface, and consequently it can have but one-fourth the brilliancy.

**61.** Light proceeds from a luminous body equally in all directions. It always moves in straight lines unless the medium through which it passes varies in density. Thus, if it passes through a body of air that is warmer in one part than in another it will be deflected, and the object viewed will appear out of its true position.

**62.** When light falls obliquely on a plate of glass, its direction is changed within the interior of the glass; this change of direction is called **refraction.** When the light emerges from the opposite surface of the glass, its direction is again changed. If the surfaces are parallel, the light will resume its former


FIG. 32

direction, as shown at *A*, Fig. 32; but, if they are not parallel, the ray will be permanently deflected from its course, as shown at *B*. On entering the glass, the ray of light *a* will be bent or refracted to the line *d*, thus making a larger angle with the surface of the glass than the original ray. When it leaves the glass, it will be again bent, but to a smaller angle with the surface from which it emerges. If an object at the point *c*, in either case, is looked at from the point *a*, it will appear to be located at *b*.

The refractive powers of glass, ice, crystals, water, oil, and gas differ greatly. Any of these substances may be employed, in the form of lenses, to concentrate or disperse light. A certain kind of crystal called Iceland spar refracts light twice simultaneously, causing objects seen through it to appear double.

**63.** Light that is scattered in many directions is said to be **dispersed.** Thus, light dispersed by reflecting it from a roughened or corrugated surface, or by transmitting it through a shade or screen of glass having a frosted or corrugated surface. Light that is transmitted through white or opal glass is not dispersed, but is merely reduced in intensity. Usually, however, the surfaces of such shades are corrugated, producing more or less dispersion. One of the best materials for the dispersing of light is frosted or ground glass.

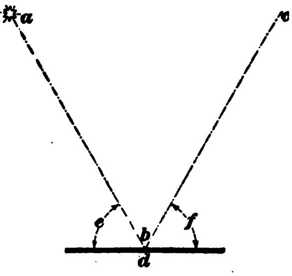

FIG. 33

**64.** When light falls on a mirror, part of it will be turned back or turned aside from its original path; this change of direction is called **reflection.** The proportion of light that will be reflected varies with different materials, with the condition of the reflecting surface, and with the angle at which the light strikes the reflector.

The ray of light that proceeds from the source of light to the mirror, as $a\,b$, Fig. 33, is called the *incident ray*, and the ray that is reflected, as $b\,c$, is called the *reflected ray*.

The law that governs the direction of the reflected ray is as follows: *The angle made by the reflected ray with the surface of the mirror will always equal that made by the incident ray;* that is, the angle $f$ always equals the angle $e$. If the mirror is curved, as in Fig. 34, the angles are measured to the line $h\,i$, which is a true tangent to the curve at the point $b$, where the ray strikes the mirror.

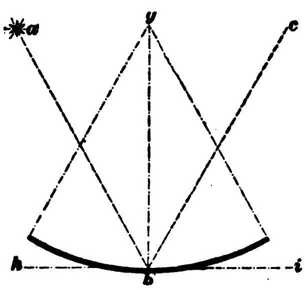

FIG. 34

**65.** Reflectors should be made of brightly polished metal, or of silvered glass attached to a metal frame. The silvered glass will not endure much heat; consequently, the polished metal should be used if the heat from the burners is likely to be excessive.

## ARTIFICIAL ILLUMINATION

### GENERAL CONSIDERATIONS

**66.** The ideal condition in artificial illumination is to have the light coming from overhead, and to have it so thoroughly diffused that no object in the room will appear conspicuously brighter than any other. Although this ideal condition is unattainable with the means now at hand, the principle should be kept always in mind so that mistakes in lighting may be avoided.

Lights of great brilliancy, when not properly shaded, are strongly condemned by occulists, as such lights not only dazzle the eye, but frequently produce impairment of vision and sometimes actual blindness. The brilliancy of the light source is the main cause of this trouble. When using artificial lights, the aim should be to illuminate all objects within the ordinary field of vision to about the same degree of brilliancy as that afforded by diffused daylight. The gaze of the human eye cannot long endure the brightness of objects lighted by the direct rays of the sun.

All artificial-light sources are much too bright to be looked at directly; therefore, they should be screened, so that whatever light reaches the eye shall be reduced to a moderate intensity.

**67.** The physiological effect of a light that shines in the eyes of a person that is looking at something else is to produce considerable nervous irritation and fatigue, if long continued. Thus, if a gas burner, a kerosene lamp, or any bright object comes within the ordinary field of vision while a person is listening to an address and is looking toward the speaker, it will cause a great deal of uneasiness. A few lights thus misplaced will fatigue an audience to a greater degree than is generally supposed. Therefore, all lights located in the vicinity of a person addressing an audience, whether above, behind, or at either side, should be fully covered by opaque screens that will prevent any light from passing toward the audience. While the

irritating brilliancy of such lights may be mitigated by means of globes of white or opal glass, they continue to be conspicuously bright and are very objectionable. The best results are obtained by using opaque screens that reflect the light back on the platform. For similar reasons, all chandeliers or pendants should be hung so high that the lights will not come within the field of vision of any person looking toward the platform or speaker.

**68.** Large audience rooms, such as churches and lecture rooms, can be illuminated to best advantage by means of small burners located near the ceiling and provided with proper reflectors to project the light downwards. These lights may be arranged in various forms and can be adapted for almost any kind of service. Their light is more agreeable than that from a single burner of equal power, because it proceeds from a large number of sources and is thus so diffused that the shadows are very soft or indistinct.

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### AMOUNT OF LIGHT REQUIRED

**69. Absorption of Light by Walls.**—The amount of light required to be emitted at the burners in order to attain satisfactory lighting in a room depends to a great extent on the color of the ceiling and walls of the room, as well as on the reflectors and shades employed in the lamp construction. Rooms having either dark-colored walls or much colored drapery will require more light than they would if finished in white. The white walls reflect and disperse the light, thus aiding the general illumination, whereas colored walls, particularly dark-colored walls, reflect less in proportion to the brightness of their coloring.

**70.** The absorption of light by ordinary colored papers, as given by Dr. Louis Bell, is shown in Table II.

This table shows that ordinarily from 50 to 75 per cent. of the light directed against the walls is absorbed by them; the remainder is reflected. It also shows how important it is to use light-colored papers or other finishes on walls of rooms that must be lighted profusely at a reasonably economical cost.

**71. Number of Open-Flame Burners.**—The rule commonly used for computing the number of ordinary 5-foot open-flame burners that will be required to illuminate a large room properly is as follows:

**Rule.**—*Divide the area of the floor of the room, in square feet, by 40; the quotient will be the number of burners required.*

One 5-foot burner is assumed to give a light of 16 candlepower. The amount of light required is from 16 candlepower to a floor space of 40 square feet in large rooms, to 8 candlepower in small ones, or from .4 to .2 candlepower for each square foot of floor space. The amount of light given by this rule is for general illumination only; it is ordinarily insufficient for reading and writing purposes.

TABLE II

ABSORPTION OF LIGHT BY DIFFERENT KINDS OF PAPERS

| Kinds of Paper | Light Absorbed Per Cent. |
|---|---|
| Ordinary foolscap | 30 |
| Orange | 50 |
| Yellow wall | 60 |
| Light pink | 64 |
| Light blue | 75 |
| Brown | 80 |
| Blue-green | 88 |
| Deep chocolate | 96 |

**72. Number of Incandescent Burners Required.** The efficiency of different lighting systems varies widely. In indirect lighting in which all the light is first reflected to the ceiling, not more than 25 per cent. of the light produced reaches useful points for reading or similar work, if the walls are dark. On the other hand, where efficient reflectors are used in rooms with light walls, as high as 60 per cent. of the light may reach the useful plane, which is considered to be 30 inches above

the floor. This should not be taken, however, as representing all the useful light, for in nearly all cases adequate illumination of side walls and ceilings is also necessary.

In recommending lamps for residences, the fact must be borne in mind that wall coverings as well as shades, etc. may be altered from time to time, so that lamps must be furnished of such size as to produce comfortable illumination under the most adverse conditions.

**73.** In residence lighting, good results will be obtained by providing 1 cubic foot of gas an hour for each 25 square feet of floor space. Knowing the size of the room and the hourly gas consumption of the lamp, the number of lamps may be obtained from the formula:

$$N = \frac{A}{25Q},$$

in which $A$ = area of room;
$Q$ = hourly gas consumption of one lamp;
$N$ = number of lamps.

The number of lamps found by this formula will ordinarily furnish enough illumination for a person to read easily in any part of the room.

EXAMPLE.—How many incandescent gas lamps consuming 1.6 cubic feet an hour each should be installed in a room 12 ft. × 16 ft.?

SOLUTION.— $12 \times 16 = 192$. $\frac{192}{25 \times 1.6} = 5$. Ans.

**74.** In churches, stores, etc., there is more necessity for distributing most of the light downwards, and efficient reflector shades are generally used. In this case inverted lamps are preferable. For auditoriums, halls, churches, etc., the formula just given may be used by substituting 40 for 25, and considering only inverted lamps with efficient reflector shades.

EXAMPLE.—How many inverted incandescent gas lamps each consuming 10 cubic feet an hour, will be required to light a hall 30 ft. × 80 ft., provided efficient reflectors are used?

SOLUTION.— $30 \times 80 = 2{,}400$. $\frac{2{,}400}{40 \times 10} = 6$. Ans.

**75.** In stores, a higher illumination is necessary. It is best to use inverted lamps with efficient reflector shades according to the following formula:

$$N=\frac{A}{16\,Q}$$

This number of lamps will provide ample illumination even for clothing stores. The owner of a store building should always consider the possibility that the building may some day be devoted to purposes demanding a high intensity of illumination, and install sufficient gas outlets for this purpose, though only a part of them may be used at first. This method is more satisfactory than running exposed piping to care for future additions, or to be put to the expense of installing new fixtures taking a greater number of lamps.

**76. Location of Outlets.**—A sketch of the ground plan should be made, and subdivided into squares having approximately equal areas. The size of these subdivisions will usually depend on the height of the ceiling and the number of lamps at each outlet, but will sometimes be determined by the structure of the building or the most advantageous locations for lamps. The smaller the subdivisions, the more uniform will be the illumination and the more expensive the installation.

A subdivision should be selected for trial and the height of lamps above the floor calculated from the formula:

$$H=2.5+\frac{D}{2};$$

in which $H$ = height of lamp above floor, in feet;
$D$ = greatest side of subdivision.

If the ceiling height permits this location of the lamp, the arrangement may be regarded as satisfactory. If not, select a smaller subdivision that will permit the proper lamp location.

EXAMPLE.—Determine the proper locations for inverted gas lamps with efficient reflector shades for lighting a store 30 ft. × 70 ft. with 10-foot ceilings.

SOLUTION.—If the room is subdivided into areas 15 ft. one way, the other dimension will be 14 ft. (14 being the nearest number exactly dividing

into 70). Placing outlets in the centers of these areas will give two rows of outlets of five each. The height of mantles above the floor will be: $H=2.5+\frac{15}{2}=10$ ft. As this is the height of the ceiling, this arrangement cannot be used without cutting a recess in the ceiling to permit bringing the mantle to the height of 10 ft.

Trying 10-ft. square subdivisions, three rows of outlets of seven each, or twenty-one outlets, are obtained. The mantle height will be:

$$H=2.5+\frac{10}{2}=7.5 \text{ ft.}$$

The lamps should, however, be placed at such a height as to remove the light source from the range of vision as nearly as possible. It should be remembered that the formula for heights is to enable us to find the least height at which the lamps may be hung to secure uniform illumination. It is nearly always advantageous to go above this minimum, but never below.

If it is decided to try lamps consuming 4 cu. ft. of gas hourly, the number required, according to Art. **74**, will be $\frac{30\times70}{16\times4}=33$ burners, which must be distributed equally among twenty-one outlets. As this is impossible, either the number of outlets must be increased to thirty-three (three rows of eleven each giving subdivisions 10 ft. × 6 ft., or four rows of eight each, giving subdivisions $7\frac{1}{2}$ ft. × 9 ft.) allowing one burner to each outlet, or the number of outlets must be decreased and two lamps placed at each outlet. This result may be accomplished by using three rows of six outlets each, giving subdivisions 10 ft. × $11\frac{1}{2}$ ft. The latter arrangement will require for symmetry thirty-six lamps to be placed with mantles $2.5+\frac{11.5}{2}=8.25$ ft. above the floor. This arrangement will be the least expensive to install, but will cost about 10 per cent. more to operate than the previous one. It must be understood of course that the results of lighting systems cannot be controlled or predetermined to the degree of accuracy to which these calculations are made, but the more accurate the calculations, the better are the results obtained.

It has been assumed in the foregoing that reflector shades having a suitable distribution will be used. The same mantle heights will serve for ball globes, but a greater number of lamps will be required.

**77. Illumination Problem.**—Assuming a men's furnishing store as shown in Fig. 35, in a city where rather high intensities of illumination are desired: How many incandescent lamps, each consuming 10 cubic feet of gas an hour, will be required to light the store, if efficient reflector shades are used? The store is 89 feet long by 14 feet 6 inches wide,

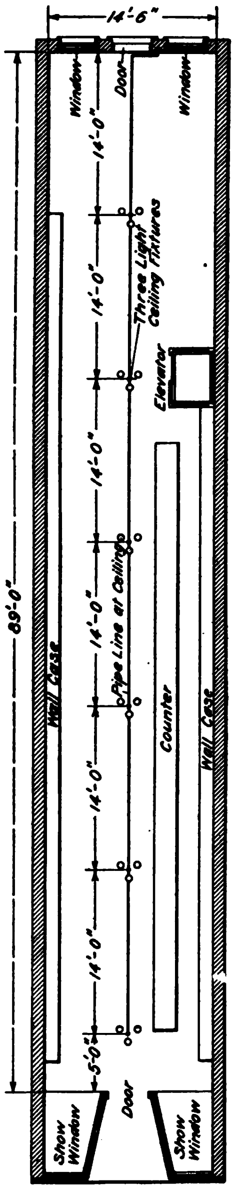


FIG. 35

having a ceiling 15 feet 9 inches high, and a floor area, consequently, of 1,290 square feet. This floor area in practice, however, is reduced by deducting for the wall cases to approximately 1,000 square feet.

According to the formula given in Art. **67**, $N = \frac{A}{16Q} = \frac{1,000}{16 \times 10} = 6$ lamps will be required.

The store being quite narrow, only 14 feet 6 inches wide, one line of gas pipe running along the center is sufficient, and if six three-mantle fixtures are used as shown in the figure, a very satisfactory illumination will be obtained.

The window illumination is not included in this calculation, as the windows usually are more intensely lighted for display purposes, and are a lighting problem in themselves.

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## MEASUREMENT OF LIGHT

**78.** Light can be measured only by its illuminating effects. As it cannot be absorbed and stored, as may be done with heat, quantitative measurements are impossible. The capacity of the human eye for the perception of light is comparatively small. It is unable to perceive very faint lights and it is dazzled and confused by lights of great brilliancy. Photographic plates are affected by faint lights that are invisible to the eye; thus, photographs of the sky reveal a multitude of

stars that are not visible even with the aid of the strongest telescopes. The unaided eye is unable to judge of the relative intensity of various lights with any reasonable approach to accuracy.

The art of measuring the comparative intensity of lights is called **photometry.** There are several methods of making these measurements—chemical, electrical, and mechanical—each of which is peculiarly suited to special cases. The method employed for general purposes is to compare the illuminating power of the light under examination with that of a light of standard intensity.

**79. Units of Light Measurement.**—The following terms are used by illuminating engineers in the United States:

**Candlepower** is the unit of intensity of the light; it is the amount of light given by a sperm candle burning at the rate of 120 grains an hour. The candle is burned in still air. A standard is maintained at the National Bureau of Standards at Washington, D. C.

**Foot-candle** is the unit of illumination; it is the light produced by a standard candle on a surface at a distance of 1 foot from the flame.

**Carcel,** which is a larger unit than the foot-candle, and is sometimes used for measuring very large lights, is the flame of a certain oil lamp called the carcel lamp, and the unit thus derived is called 1 carcel. This term is seldom used in the United States.

**Lumen** is the quantity of light that will produce a normal illumination of 1 foot-candle over a surface of 1 square foot. A candle produces theoretically 12.57 lumens.

**Plane** or *working plane* is the surface or assumed plane at which the illumination is required, which ordinarily is 2 feet 6 inches above the floor, this being about the average reading or writing height.

**Spherical candle** is the whole amount of light given off in all directions by a standard candle being measured at a distance of 1 foot from the center of the flame.

**80. Instruments.**—All instruments that serve to measure the comparative brilliancy of lights are properly called

*photometers*, but only those that are suitable for measuring ordinary gaslights, etc. will be described here.

One of the oldest of these instruments, called the *Rumford photometer*, is shown in Fig. 36. It consists of a table having

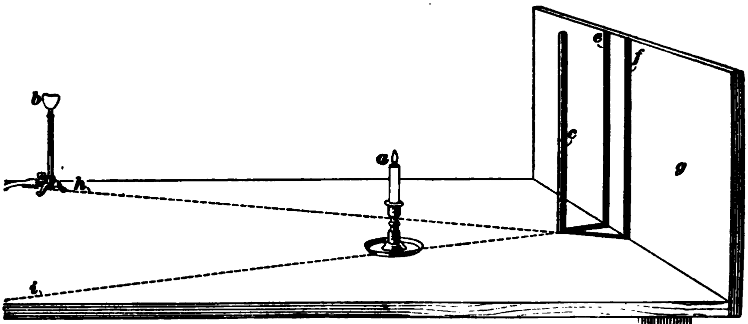


FIG. 36

a black wooden post *c*, standing erect as shown, and a screen *g*, which receives the shadows of the post that are cast by the lights *a* and *b*. The candle *a* is the standard light and *b* is the light whose intensity is to be measured. The lines *h c* and *i c* must be at exactly equal angles with the screen, and the lights are moved back and forth along these lines until the shadows *e* and *f* appear of exactly equal blackness. The powers of the two lights are then computed by dividing the

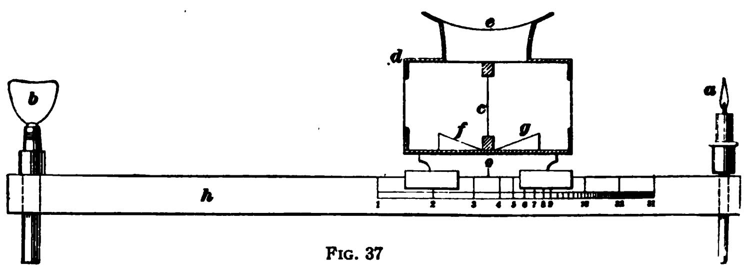


FIG. 37

square of the distance *b c* by the square of the distance *a c*, the quotient being the candlepower of the light *b*.

This method is very inaccurate and is not to be recommended, because the eye is unable to compare the shadows *e* and *f* with the requisite accuracy.

**81.** The *Bunsen photometer*, shown in Fig. 37, operates on a different principle from the Rumford. A diaphragm *c* is illuminated on its opposite sides by the light *b* and the standard candle *a*. The observer looks down through the tube *e* into mirrors *f* and *g*, and thus sees the reflection of both sides of the diaphragm at the same time. If they appear of unequal brilliancy, the sight-box *d* is moved along the bar *h* until they become equal. The candlepower of the light *b* is then found by dividing the square of the distance *b c* by the square of the distance *a c*; usually the bar is graduated, as shown, so that no calculation is necessary.

FIG. 38

**82.** The two constructions of the diaphragm are called the spot diaphragm and the star diaphragm. The *spot diaphragm* is shown in Fig. 38. The center *a* is a disk of opaque white paper. The ring *b* is made of white paper saturated with paraffin and is translucent. The outer part *c* is blackened. When this diaphragm is unequally illuminated on its opposite sides, the ring *b* looks darker, or brighter, than the center *a*, but when the illumination is exactly equal, all difference disappears and the spot *a* becomes indistinguishable.

The *star diaphragm* is shown in elevation at *A*, and in section at *B*, Fig. 39. It consists of a piece of white writing paper *a* of moderate thickness, having a star-shaped figure cut out of its center, and a sheet of thin white writing paper *c*, of best quality, which is doubled so as to enclose the piece *a*. The diaphragm is lightly squeezed between two pieces of glass *b*. Care is taken in cutting the star to make every point and line clear and sharp. When the reflection of the diaphragm is seen in the mirrors, the images will vary in distinctness if the lights

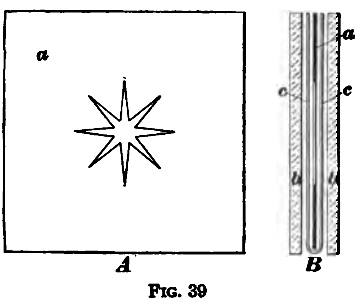

FIG. 39

are unequal. The sight-box *d* in Fig. 37 is then moved along the bar until both images of the star appear equally sharp and clear.

**83.** It will be observed that the methods of testing employed in the photometers are quite different. In the Rumford method, the observer judges the equality in blackness of the shadows produced; in the Bunsen method, using the spot diaphragm, he judges by the equal brightness of the opposite sides of the diaphragm; and when using the star diaphragm, he judges by the equal clearness and distinctness of the two images of the star. The Rumford method has been discarded for the more accurate Bunsen method. Both the spot and the star diaphragms are widely used, but the star diaphragm is preferred because of its greater accuracy.

TABLE III

GRADUATIONS OF BUNSEN PHOTOMETER BAR

| C. P. | $x$ | C. P. | $x$ | C. P. | $x$ | C. P. | $x$ |
|---|---|---|---|---|---|---|---|
| 1 | 50.00 | 11 | 23.17 | 21 | 17.91 | 31 | 15.22 |
| 2 | 41.42 | 12 | 22.40 | 22 | 17.57 | 32 | 15.02 |
| 3 | 36.61 | 13 | 21.71 | 23 | 17.25 | 33 | 14.83 |
| 4 | 33.33 | 14 | 21.09 | 24 | 16.95 | 34 | 14.64 |
| 5 | 30.60 | 15 | 20.52 | 25 | 16.67 | 35 | 14.45 |
| 6 | 28.98 | 16 | 20.00 | 26 | 16.40 | 36 | 14.28 |
| 7 | 27.43 | 17 | 19.52 | 27 | 16.14 | 37 | 14.12 |
| 8 | 26.12 | 18 | 19.07 | 28 | 15.90 | 38 | 13.96 |
| 9 | 25.00 | 19 | 18.66 | 29 | 15.66 | 39 | 13.80 |
| 10 | 24.04 | 20 | 18.27 | 30 | 15.43 | 40 | 13.65 |

**84.** In practice, the distance between the centers of the lights is usually made 100 inches for a Bunsen photometer. The bar is graduated in accordance with Table III, where the abbreviation C. P. means candlepower, and $x$ the distance, in inches, between the standard candle and the disk of the sight-box.

**85.** The distance $x$ in Table III, equal to $a\,c$ in Fig. 37, may be computed for any distance between the centers of the lights and for any candlepower by the following rule:

**Rule.**—*Divide the distance between the centers of the lights, in inches, by the sum of 1 and the square root of the candlepower.*

Or,
$$x=\frac{d}{1+\sqrt{c}},$$

in which $d$ = distance between centers of lights;
$c$ = candlepower.

EXAMPLE.—If the distance between the flames of the light to be tested and of the standard candle is 150 inches, what should be the distance between the diaphragm and the standard candle for 64 candlepower?

SOLUTION.—Applying the rule just given,

$$\text{distance}=\frac{150}{1+\sqrt{64}}=16.67 \text{ in. Ans.}$$

**86.** When testing high-power lights at the standard distance of 100 inches, such as incandescent gaslights, it is advisable to use two or more standard candles instead of one. The candlepower readings corresponding to the graduations, as given in Table III, must then be multiplied by the number of standard candles used to ascertain the candlepower of the flame being tested.

**87.** Any good mechanic can construct a photometer like that shown in Fig. 37, which will be sufficiently accurate for all ordinary purposes. By its aid he can investigate for himself and can acquire much valuable information. When using the photometer, care must be taken to prevent the entrance of light into the sight-box from any other source than the lights that are to be compared. A screen of black velvet should be suspended behind each light to prevent any light from being reflected toward the sight-box. A dark room is best to operate in, even if the instrument is protected with curtains and screens of black cloth. When testing gas, the pressure must be kept uniform, and the rate of combustion should be carefully measured.

**88.** The candlepower of ordinary illuminating gas is measured while burning at the rate of 5 cubic feet an hour, under a pressure of .5 inch of water column. To secure very exact measurements, small corrections must be made for the temperature of the gas and for the moisture contained in it. The candle should always be weighed before and after each test, and allowance must be made in computing the candlepower of the light under examination, if the rate of consumption of the candle varies either way from the standard rate of 120 grains an hour.

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**EXAMPLES FOR PRACTICE**

1. How many 5-foot open-flame burners should be placed in a parlor measuring 14 ft.×20 ft.? Ans. 7

2. How many incandescent lamps, each consuming 10 cubic feet an hour, are required for a hall measuring 60 ft.×80 ft., if efficient reflectors are used? Ans. 12

3. Suppose that the standard candle and the light to be tested are 120 inches apart, how far should the diaphragm be from the standard candle for 16 candlepower? Ans. 24 in.

# DOMESTIC USES OF GAS
(PART 2)

## GAS HEATING

### BURNER CONSTRUCTION

#### BUNSEN BURNERS

**1. Portable Bunsen Burner.**—All burners that are designed to produce heat rather than light are constructed to mingle the gas with air before burning. They therefore belong to the class known as *atmospheric burners*. The most commonly used design of atmospheric burner is the Bunsen burner, a portable form of which is shown in Fig. 1. It consists of a gas tube *a* that projects part way into a larger tube *b*, which is called the mixing tube, or mixing chamber. Air is admitted through holes *c*, which can be partly or entirely closed by means of the collar or slide *d* to regulate the amount of air admitted. The gas issuing from pipe *a* and the streams of air from the holes *c* mingle in the upper part of the tube *b* and form a mixture that will burn over the mouth of the tube. The flame will be quite large and unsteady, and if illuminating gas is burned, it will show a pale blue color with a tendency to green. If the proportion of air admitted through the holes *c* is too large, the flame will flash back with a sharp puff or explosion, and will then burn at the orifice of *a* with an ordinary yellow, smoky flame. To prevent this, the slide *d* must be adjusted so as to restrict the supply of air to just below the

explosion limit. If the air supply is much too large, the explosion may be sufficiently violent to extinguish the flame.

**2.** The gas and air must be thoroughly mixed before they reach the orifice or orifices where the mixture is burned. The mixing operation requires a sensible amount of time; therefore, the mixing chamber must be large enough to afford the gas ample time to mingle with the air properly while passing from the supply pipe to the orifices of the burner.

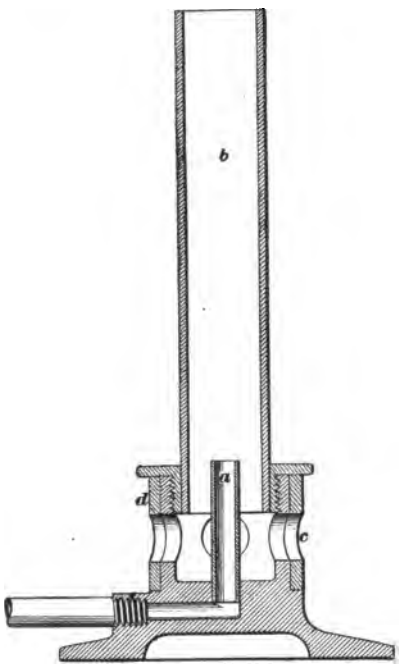


FIG. 1

The air inlet should always be at the lowest part of the mixing tube or burner, so that none of the gas may escape backwards through it. Good service can be got from a burner by regulating both the air and gas supply at the same time. For this purpose compound cocks are made that control both inlets simultaneously.

**3. Gas-Range Burners.**—The general design of the type of Bunsen burners commonly employed for cooking stoves is shown in Fig. 2 (*a*), and a gas-cock used for controlling a supply of gas to this burner is shown in view (*b*). In the illustration the perforated burner caps *a* and *b* are removed so that the interior of the bowls *c* and *d* can be cleaned; *a* shows the top of the cap and perforations, while *b* shows the interior construction and method of fitting the caps to the bowls. The gas and air are mixed within the tubes *e* and the mixture is burned by means of a large number of small flames that issue from the perforations in the top of the burner. Each burner is provided with an air mixer *f*

for properly adjusting the amount of air to the burners. A sectional view of the gas-cock used in connection with the burner is shown in view (*b*); the valve is attached to the gas-supply pipe *g* and the end *h* is inserted into the mixing chamber *f*. The gas entering from *g* passes through the orifice *i* into the mixing chamber. The flow of gas through the orifice *i* is regulated by the adjusting screw *h*. The stop *j* is held firmly in place by the screw *k* and spring *l*.

Each burner should have its own mixing tube and gas-cock so that one or more burners may be used as desired. The amount of gas consumed by a burner varies with the size; usually it is between 10 and 18 cubic feet an hour.

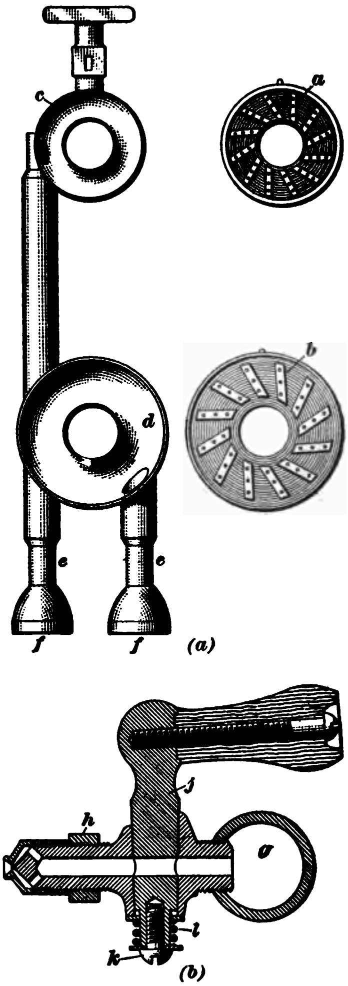


FIG. 2

**4. Inverted Burners.** For some purposes burners are made to work in an inverted position; that is, with the flame on the under side. They are thus enabled to radiate heat over the top surface of materials exposed below them. This feature is of great value in cooking operations and for certain manufacturing purposes. Of course, the air inlet must then be at a lower level than the bottom of the burner.

**5. Slit Burner.**—There are many different shapes of burners on the market, but the principle of combustion is the

same in all; their chief difference is found in their adaptability to the different makes of stoves. Generally speaking, burners that are least liable to foul with grease or lampblack, or that can be most easily cleaned by the cook or other operator are the best. Ease of cleaning is a prominent feature of the so-called slit burners; they differ from those having small circular perforations only in that they have slits at which the mixture is burned, the slits being large enough to be easily cleaned with a thin knife blade.

**6. Perfection Burner.**—The burner shown in Fig. 3 has the jets arranged in the from of a star, whence this type derives the name of *star burners*. The design illustrated is known to the trade as the Perfection burner. The perforations are

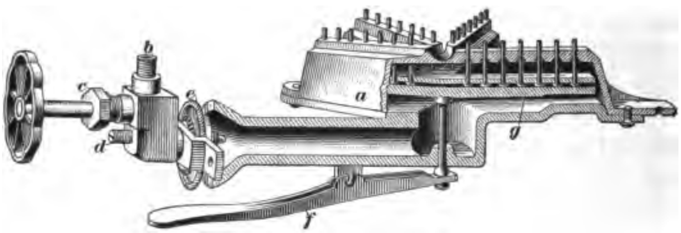



FIG. 3

in the arms *a* of the star; the gas-supply pipe is connected at *b*. The valve *c* is used to turn on or shut off the gas supply to the burner. A setscrew needle valve *d* forms a gas check, which, when adjusted to suit the gas pressure and the requirements of the burner, prevents the operator from having too large a flame, even when the valve *c* is opened fully. A shutter *e* can be revolved until it screws up tightly against the funnel-mouthed inlet of the mixing tube, when the air supply will be entirely shut off; it may be adjusted so that the exact air supply required will be admitted, when it is secured in position by a locknut. The principal feature of this burner is the cleaning attachment. It is composed of a lever *f* and a star-shaped cleaner *g* provided with a number of small rods or prongs projecting upwards. They are located in such a position that when the long arm of the lever is pressed down, the prongs are pushed

up through the burner holes, as shown, and the burner holes are thus cleared of lampblack or other obstructions. When the pressure is removed from the lever the weight of *g* will hold the prongs down inside the burner and gas can freely flow through it.

**7. Simmering Burner.**—The ordinary large ring burner gives too much heat for the method of cooking known as *simmering*, and hence a small single-flame Bunsen jet or a very small burner *a*, Fig. 4, is supplied for this purpose to gas-cooking stoves. The gas supply to the simmering burner is controlled by the cock *b*. The illustration shows common practice not only in locating several burners on a gas stove, but also in the location of the mixing chambers *c*. The gas header or

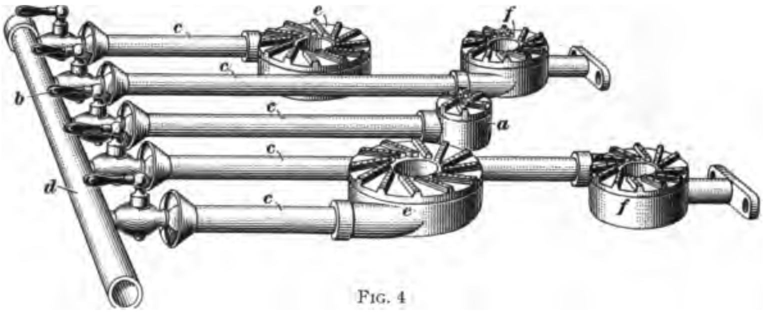
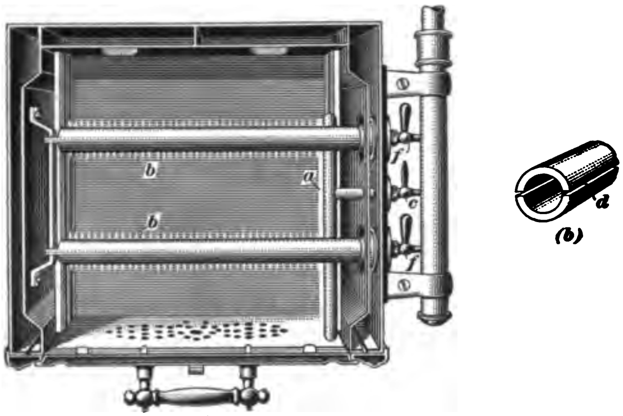



FIG. 4

branch pipe *d* is usually placed in front of the cooking stove. Large burners are located at *e* and smaller burners at *f*. A simmering burner is placed in every good gas stove, partly for convenience and partly as a means of saving gas, as a simmering burner usually consumes only from 2 to 5 cubic feet of gas an hour.

**8. Oven Burner.**—For the purpose of heating the ovens of gas ranges many different forms of burners are used. The best oven burners are those that distribute the heat uniformly. Oven burners are located beneath the ovens, and should be capable of being lighted from the outside by means of an igniter. Fig. 5 (*a*) shows how an igniter *a* may be attached for two oven burners *b*. It is simply a tube leading from the igniter cock *c*

to the burner holes. The tube is split on both sides, as shown in detail in (*b*), the openings *d* extending uninterrupted from *c* to the burners. To ignite the burners, therefore, the cock is turned on full while a light is held close to the slot at the point outside of the oven, when a flame will travel along the slots and reach the burners. The burner cocks *f* are now opened and the burners become ignited; the cock *c* is then closed. The igniter is not an atmospheric burner and therefore burns with




(a)

FIG. 5

a yellow flame, which makes the igniter more certain and safe than one that burns on the Bunsen principle.

**9. Vaporizing Burner.**—Devices for generating gas from oil by means of heat, and combined with atmospheric burners proportioned to burn properly the gas thus produced, are called *vaporizing burners*. They are commonly used with gasoline, but other and heavier oils may be employed by modifying the vaporizer and burner to suit. Oil vapors contain such an abundance of carbon that the quantity of air required to burn them properly is much greater than that needed with ordinary illuminating gas.

The liquid is vaporized only as fast as it is used, and the heat required for vaporization is taken from the flame; usually some of the waste heat is thus utilized. The general method

of construction is to have the oil reservoir elevated above the burner, so that the liquid will flow down to the vaporizer by gravity. The gas produced may be burned in any properly proportioned atmospheric burner.

**10. Care of Atmospheric Burners.**—The atmospheric burners used in cooking stoves, etc. seldom give any trouble if they are properly proportioned and adjusted. If the mixing tube is too small, the supply of air is apt to be insufficient, and to be imperfectly mixed with gas, thus causing the burner to smoke. The burners frequently become foul, and are sometimes clogged with burnt grease, etc. Each hole or jet should then be cleaned by inserting a wire, and the mixing tube should be inspected and cleared of all lint and dirt.

The trouble with gas grates, gas logs, and similar gas heaters is that they will sometimes blow and *snap out* or extinguish the flame, when the pressure in the supply pipe becomes unusually low, leaving the air supply nearly unchanged, while the gas supply diminishes. The relative proportions are thus altered until the mixture becomes explosive. This trouble may be remedied by adjusting the burner and air inlet to work properly at a certain minimum pressure, which is assumed to be the lowest that will occur, and using a pressure reducer or governor to maintain the supply of gas to the heater at that pressure.

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## FLETCHER BURNERS

**11.** The **Fletcher, or solid-flame, burner,** is shown in Fig. 6. That part of the apparatus that serves to mix the gas and air is similar in principle to that used in the Bunsen

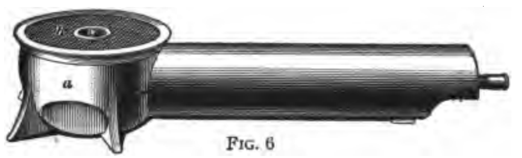


Fig. 6

burner, but the method of burning the mixture is quite different. The top of the chamber $a$ is covered with stout wire

gauze *b*, and the gas burns as it issues through the meshes of the gauze. As the gas is already provided with nearly or quite all of the oxygen that it requires for combustion, it burns close to the gauze with a small, compact flame of great intensity. The color of the flame, when using ordinary illuminating gas, is a bright green with a few traces of blue. A larger and more diffused flame can be obtained by diminishing the air supply. As the flame then spreads out, in order to secure from the atmosphere the oxygen that is lacking, it becomes less intense, appearing more like the flame from a Bunsen burner. When the large flame is used, the central air tube *c*, which passes entirely through the chamber *a*, supplies air to the middle of the flame.

FIG. 7

**12.** The Fletcher burner is able to develop a higher heat from the gas than the Bunsen burner, because it permits a larger proportion of air to be mixed with the gas. If an attempt is made to burn, in a Bunsen burner, a mixture having the full proportion of air necessary for combustion, the flame will blow back. The same mixture will, however, burn perfectly in a Fletcher burner, because the flame is prevented from blowing back by the wire gauze *b*. Usually one or more partitions of wire gauze are provided in the interior of the burner, to act as fire-checks in case the main gauze should become broken.

The Bunsen burner may be transformed into a Fletcher burner to great advantage by providing it with gauze, as shown at *a* and *b*, Fig. 7. With this arrangement the flame can be turned down exceedingly low without danger of blowing back or snapping out.

### FIRE-CHECKS

**13.** In burning explosive mixtures of air and gas, some device, called a **fire-check,** must be employed to confine the flame to a certain place and thus prevent its spreading backwards into the mixing chamber or reservoir.

Before combustion can take place, the temperature of the gaseous mixture must be raised to a certain degree, called the *point of ignition*. Now, if the mixture can be separated from the flame by some kind of a screen that will not become heated to the point of ignition, it is evident that it cannot be set on fire by contact with the screen.

**14.** The device most frequently employed as a fire-check is a partition of wire gauze through which the mixture of air and gas is forced to pass. As the gas passes through the meshes of the gauze, it is carried some little distance beyond the surface before it burns; consequently, the flame does not actually touch the gauze. The heat radiated from the flame rapidly heats the wires, and would soon raise them to incandescence if no cooling influence were brought to bear on them. But the stream of cold air and gas that passes through the meshes absorbs the heat from the wires and keeps them at a moderate temperature. If there is no current through the wire gauze, and if fire is maintained on one side of it and an explosive mixture on the other, the safety will depend entirely on the rapidity with which the cold mixture can absorb and carry off the heat from the wires. Usually the conductive power of the air and gas is not sufficient to keep the temperature of the wires below the point of ignition for any considerable length of time, and an explosion consequently results.

An explosion on one side of a gauze partition will not set fire to an explosive mixture on the opposite side, unless the force of the explosion bursts a hole in the gauze and thus permits fire to pass, because the temperature of the flame will fall rapidly, and it will die out before the gauze becomes heated to the point of ignition.

**15.** Devices other than a wire-gauze screen are sometimes used for fire-checks. The explosive mixture may be passed

through metal tubes having a small bore and considerable length, or through narrow passages between flat metal plates; the essential point is that the heat that is received from the flame shall be conducted away or dissipated so rapidly that the temperature of the metal cannot be raised to the point of ignition at the end where the mixture enters.

The mesh and the size of the wire composing the gauze are matters of great importance. The wire should be of brass or copper, woven with twenty-eight or more wires to the inch, the gauze having not less than 784 meshes to the square inch. Gauze made of iron or tinned wire is very liable to be spoiled by rust holes, and the metal does not conduct the heat away fast enough. It should not be used for fire-checks.

## COOKING APPLIANCES

### HOT PLATES

**16.** A **hot plate** is a small stove arranged to be set on a box or table. It may have one, two, three, or more atmospheric burners set side by side, and is called accordingly a *one-holed*, *two-holed*, or *three-holed* hot plate, as the case may be. A two-holed hot plate is shown in Fig. 8. Each burner *a*

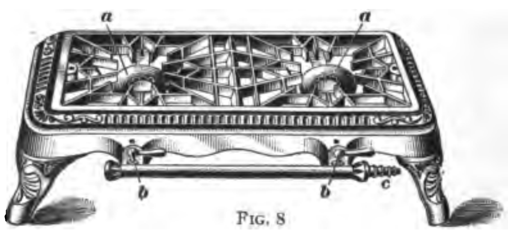


FIG. 8

is supplied with a separate air mixer and cock *b*. Connection between the hot plates and the gas supply is accomplished by means of a rubber hose attached at one end to a conveniently located hose cock on the gas-pipe system and at the other to a hose coupling *c*. The hot plates may therefore be moved

about or set aside as occasion requires. No oven is attached to the hot plates, but portable ovens may be set over the burners and excellent results in baking obtained.

The supply of air and gas should be adjusted so that the flame burns at *a* without any appearance of white tips. If the flame shows white in spots, like the flame from an ordinary illuminating burner, it indicates that too little air is being supplied, and the flame will smoke any cooking utensil that may be placed over it. If too much air is supplied, the flame will flash back through the burners, burn inside the mixing chamber, and thus become useless for cooking purposes.

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### GAS RANGES

**17. Construction.**—In Fig. 9 is shown a modern gas range having four burners *a* on top, a large baking oven *b*, a small baking oven *c*, and a broiling oven *d*. Gas is supplied to the different burners through the pipe *e*. The gas-cock for the lower oven *b* is shown at *f*. Gas is delivered to oven *c* through the pipe *g* and controlled by the gas-cock *h*, while the oven *d* is supplied with gas through the gas-cock *i*. The gas-cocks *j* control gas to the burners *a* on top of the range; the small valve *k* supplies gas to a simmering burner not shown. A shelf for dishes is shown at *l*; the hood *m* when connected with a chimney serves to carry off the steam and fumes when the range is in use.

**18.** Gas ranges are sometimes made with only three burners on top, and sometimes with six or more burners, as in the case of hotel ranges. A simmering burner consumes but little gas and produces a flame just large enough to keep the food simmering. The same result can be obtained by very carefully turning down the ordinary atmospheric burner, if it is properly designed. As the flames must be turned down very low, however, even a very slight draft of air may extinguish them, when the gas may mingle sufficiently with the atmosphere of the room to form an explosive mixture.

The burners used under the ovens should be so constructed as to distribute the heat uniformly to the oven and yet be

capable of being checked down. It is always best for convenience and to prevent explosions to have a pilot light arranged to light the oven burners. The burners on the top of the range are of cast iron and are usually circular or star-shaped.

**19. Operation.**—Any difficulty in the proper operation of range burners arises from the stoppage of the burner by

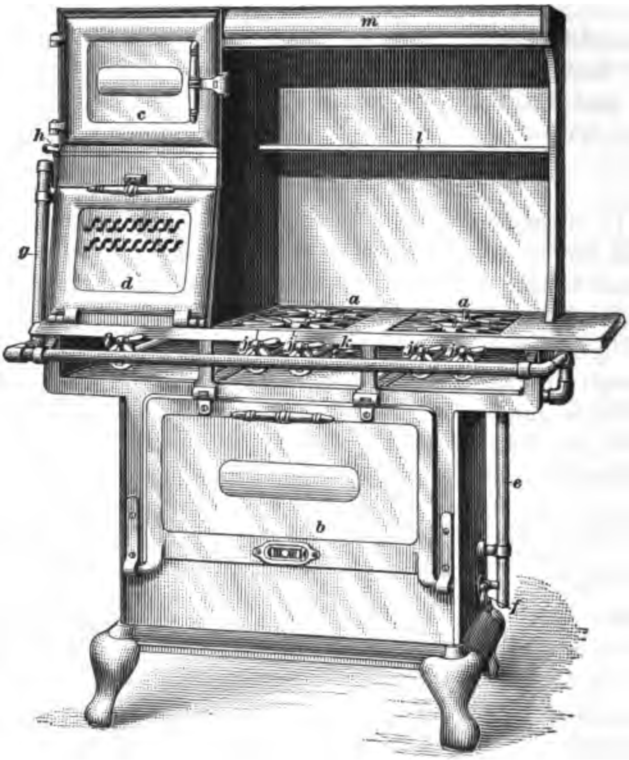



FIG. 9

spilled grease, etc. or the filling of the burner with lampblack, when it has been allowed to flash back and then been left burning. In either case the burners should be taken apart and cleaned.

In advising a beginner how to operate a gas range, particular emphasis should be laid on the fact that the oven burner

must never be turned on unless it is lighted at once. If the oven burner is turned on and the gas is not ignited immediately, an explosive mixture may be formed in the oven, so that when a light is applied to the oven burner the gas in the oven will also ignite and produce an explosion that will frighten people badly and may possibly wreck the range. There is, however, little actual danger from such an explosion, because no burning oil is thrown about, as in an explosion of a gasoline stove.

To operate a gas range with economy, the gas should be turned off entirely when the heat is not actually needed. In baking, however, the oven should be lighted a few minutes before it is to be used. It should also be remembered that after a vessel of water has been brought to the boiling point it may be kept boiling by a very small flame.

**20. Installation.**—The size of meter connections, that is, the pipe through which gas flows from the gas-pipe system to the range, is a matter that must not be slighted. Many gas ranges and heaters give unsatisfactory results, because the connections are too small. A five-light meter is the smallest size that should be used when a gas range is to be installed.

Ordinary-sized gas ranges may be connected with ½-inch pipe if the distance to be run is not more than 20 feet. For any longer distance, ¾-inch pipe should be run; this size pipe should also be run if there is any chance of a water heater being also installed, and for ranges with more than four holes in the top. It is usually best to run the pipe line directly from the meter to the stove. A plug cock with a suitable handle should always be installed in the pipe line, to which the stove should always be connected by means of a union or long-screw nipple, so that the gas may be shut off and the stove disconnected at any time.

## BROILERS

**21.** The best appliance for broiling steaks and chops is a vertical broiler in which the steak is placed edgewise in a gridiron and broiled on both sides at the same time. By this

means a large quantity of the juice is kept in the meat. This style of broiler, which is shown in Fig. 10, is attached to the end of a range, or may be separate from it, and is thus frequently used in hotels and restaurants. A number of horizontal mixing tubes *a* supply a series of burners *b* located on both sides of the

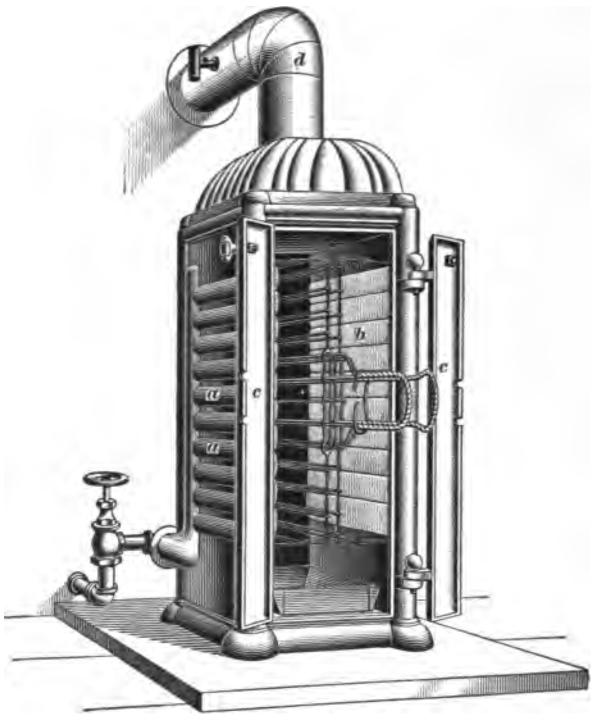



FIG. 10

broiler. If these burners are in good condition, a flat sheet of blue flame will be obtained at each side of the gridiron. Most of the broilers on the market have asbestos fibers placed between the burners. These fibers become highly incandescent and heat both sides of the meat by radiation. The doors *c* can be closed over the handles of the gridiron. The products of combustion, etc. are led to the chimney through *d*. The valve shown at the left of the broiler is for regulating the flow of gas to the mixing tubes *a* and *b*, thus controlling the intensity of the flame.

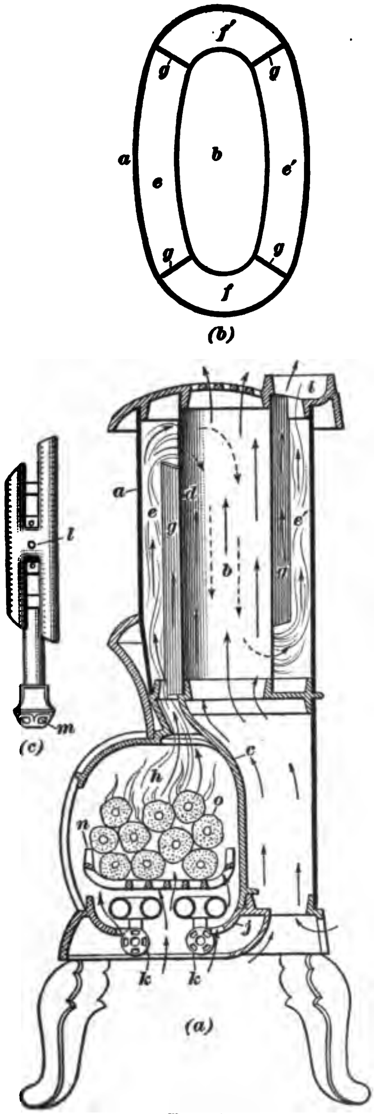



Fig. 11

## HEATING APPLIANCES

### HOUSE-WARMING GAS HEATERS

**22. Gas Stoves.**—A sectional view showing the interior construction of an efficient gas heater is shown in Fig. 11 (*a*). Heat is transmitted from the flame in three ways: by convection, by radiation, and by reflection. The circulating flue or drum *a* is made of steel with double walls, leaving a central flue or hot-air duct *b* through which cold air is brought from the floor. This air is heated by coming in contact with the corrugated cast plate *c* forming the back of the fire-chamber and the interior walls of the drum *d* before it escapes into the room from the top of the heater.

A horizontal section given in (*b*) shows the drum. It is divided into four chambers *e*, *e′*, *f*, *f′* by metal flue strips *g*, etc. In view (*a*), the heat from the burner compartment *h* passes up through the front flue *e* to the top of the heater, then down the side flues *f*, *f′*, then up through the rear flue *e′* to the chimney-flue opening *i*,

thus causing the heated products of combustion from the flame to pass around the entire drum, which affords an exceptionally large radiating surface.

The burner compartment *h* is made with a cast-iron bottom *j* with holes to permit the necessary air for combustion to be fed to the burners. The two burners *k* cover the base of the heater and each burner has a double arm with two lines of drilled openings, as shown in view (*c*). The gas enters the center of the burner at *l*, and is distributed equally to all parts of the burner. A mixing chamber for adjusting the air is shown at *m*.

Over the burner *k*, view (*a*), rests a cast-iron grate *n* filled with incandescent fuel *o* which, when the gas is burning, presents the appearance of glowing coals.

FIG. 12

**23.** Fig. 12 shows a **reflecting gas stove.** The gas is burned in an atmospheric burner connected to *a*, which occupies the upper part of the stove. The gas burns in a number of small jets, and the reflector *b*, which occupies the back and lower part of the stove, reflects heat from these flames into the room; being corrugated, it reflects irregularly, and thus diffuses the radiant heat. To give a cheerful appearance to the room in which such a heater is placed, the gas is sometimes burned without the addition of air before combustion.

**24.** Many gas heaters for house warming are built in accordance with the assumption that air can be heated by

means of radiant heat. This assumption is erroneous, because radiant heat passes through air without affecting it, except in a very slight degree. It should be borne in mind that air can be heated only by contact with hot surfaces.

Nearly all the heat radiated from a stove falls on the walls or furniture of the room and is expended in warming them. The air in the room is gradually warmed by contact with the surfaces thus heated; some of it is heated by contact with the stove itself, but none of it is warmed by the direct action of the radiant heat.

The stove shown in Fig. 11 is well adapted for heating air because it has large heating surfaces over which the air may travel. The prime requisite of an air-heating apparatus is an abundance of hot surfaces.

FIG. 13

**25.** No gas stove or heater should be permitted to discharge its products of combustion into the air of a small, closed room, because they will vitiate the air with great rapidity. Every heater in such a room should be connected by a pipe to a chimney, or should have a hood over it, which should have a free discharge into the outer atmosphere. The ordinary large rooms of dwelling houses are usually so well ventilated that small gas stoves may in many cases be used without being connected to a chimney or vent flue.

**26. Open Fireplace Heaters.**—Fig. 13 shows a gas grate designed to occupy an ordinary open fireplace. The back

plate is covered with loose bunches of asbestos fibers and is perforated with a number of fine holes. The gas is mixed with the necessary air in a chamber in the rear, and the mixture passes through the small orifices and burns on the front face of the plate among the loose fibers. The asbestos becomes incandescent and glows like an open fire of coal, emitting both light and heat. Stoves are also constructed on this plan, but they are not very efficient in heating air.

**27.** A **gas log** is shown in Fig. 14. The log is made of fireclay and is perforated with a large number of small holes, through which the mingled gas and air, or the gas only, passes out and burns. The log is hollow and its interior serves as a chamber in which the gas and air are mixed before combustion. The heat is radiated directly from the small flames that nearly cover the surface of the log.

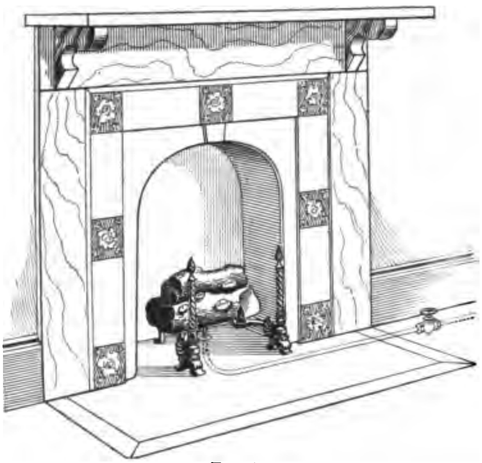


FIG. 14

Gas logs formerly were not furnished with atmospheric burners, but they had such a tendency to smoke and become covered with soot that now a mixing chamber is almost always provided. A cock or valve controlling the log should always be placed near one corner of the fireplace. Plug cocks, with special long handles having a small wheel on top, are better than valves, as they are less apt to leak.

When logs are set on the first floor of a house, the cocks should be placed below the ceiling in the cellar, so that they are readily accessible. Where the cock must be located between the floor and the ceiling of the room below, as in the case of logs set on second floors, a pocket should always be left in the

floor above the cock in order to make it accessible for inspection and repairs. Half-inch pipe should be used to connect logs 18 inches long or less; larger pipe should be used for larger logs.

**28.** Asbestos-backed gas fireplaces are more efficient heaters than logs. They are frequently provided with a gas valve at the bottom of the heater, but it is best also to place a cock on the pipe line in the same position in which a cock would be placed for a gas log.

### MISCELLANEOUS GAS-HEATING APPLIANCES

**29.** A large number of small gas-heating appliances are in common use, such as coffee urns, oyster stewers, confectioners' gas stoves, waffle stoves, cake griddles, iron heaters for tailors and for laundry use, etc. Irons heated by a burner inside of them are frequently used in large laundries. By their use, considerable time is saved, as the iron is always at the right heat and the operator need not stop to change irons. The best irons for this use have an air-hose connection as well as a gas-hose, and an air blast is supplied to the burner. These special appliances differ only in form from the appliances described; they employ the same principle of operation, which is the burning of the gas in atmospheric burners. In the mechanic arts gas-heating appliances are largely used for melting metals, annealing, soldering, hardening and tempering, case hardening, and similar manufacturing operations.

### WATER HEATERS

**30. Classification.**—Waterfronts, that is, water heaters of the form used in coal-burning cooking stoves for heating the water for kitchen boilers, cannot be used economically in connection with gas ranges because the amount of heating surface they contain is too small. Hence, special gas-burning water heaters overcoming the defect of the waterfront are made. Gas-burning water heaters may be divided into two general classes: *kitchen boiler heaters* and *instantaneous heaters*.

**Kitchen-boiler heaters,** as implied by the name, are used in connection with a kitchen boiler, serving as a storage

reservoir for the hot water. **Instantaneous heaters** have no storage reservoir; they are put in operation whenever hot water is required, and derive their name from the rapidity with which they will heat the water. There are two types of instantaneous heaters: those in which the gases of combustion do not come in contact with the water and those in which the gases of combustion come in contact with the water. The first type of instantaneous heaters may be called *closed heaters*, and contain water under pressure; the second type may be called *open heaters*, and the water in them is not under pressure.

**31. Kitchen-Boiler Heaters.**—The heaters that are used in connection with boilers are usually formed either of a collection of drop tubes, or of an iron casting made with hollow flanges, which gives a large heating surface, set over an atmospheric burner. A common design of kitchen-boiler heater employs a vertical cylindrical coil of copper pipe, through which the water may pass, and uses an atmospheric burner at the base of the coil, passing the hot products of combustion up the interior of the coil and between its convolutions. A heater of this kind, suited to a 50- or 60-gallon boiler, usually contains about 35 linear feet of $\frac{3}{4}$-inch copper tubing, and the burner is made to consume from 20 to 25 cubic feet of ordinary illuminating gas an hour.

**32.** The inlet for the water is always at the bottom and the outlet at the top when the heater is connected to a boiler. There is usually a pilot light for lighting the atmospheric burner. The pipe leading to the bottom of the heater should always be connected to the pipe from the bottom of the boiler, and the outlet of the heater should be connected in at the top of the boiler. A good heater so arranged will heat up a 30-gallon boiler in 15 minutes.

**33.** The same boiler may be connected both with a gas heater and with an ordinary range waterfront, and either or both may be used, as is desired. Fig. 15 shows a gas heater *a* connected to a kitchen boiler *b*. The heater is connected to the boiler independently of the connections from the kitchen-range waterfront *c*, so that each may be operated separately

and without interfering with the circulation of the other. When water is heated in *a*, it rises in the flow pipe *d* and enters the top of the boiler, while a corresponding quantity of cold water flows from the bottom of the boiler into the heater through the return pipe *e*. A circulation is thus maintained between the

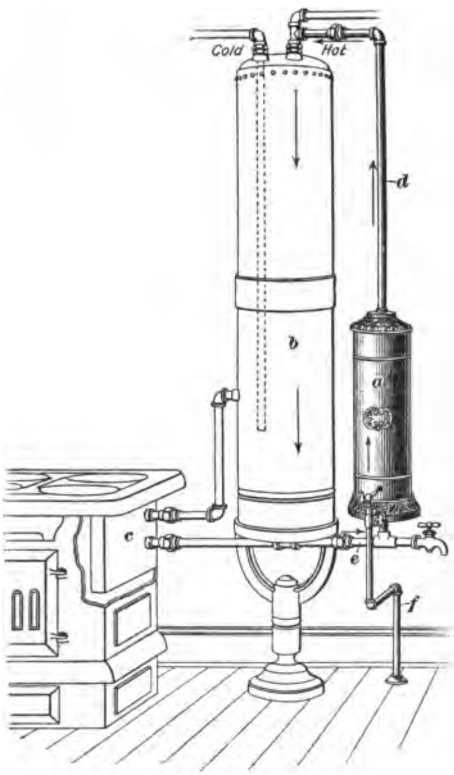



Fig. 15


Fig. 16

heater and the boiler, as shown by the arrows, and the heat of the gas flames is thus transmitted to the water. Gas is supplied to the burner by the pipe *f*. The products of combustion may pass to the chimney through a 3- or 4-inch smoke pipe, or, if the kitchen is well ventilated, may be discharged directly into it, as is done in the case illustrated in Fig. 15.

**34.** The construction of the gas heater shown connected up in Fig. 15 is illustrated in Fig. 16. This heater is composed of a number of hollow cast-iron or cast-brass sections *a*, which have a number of flues *b* passing through them. These sections are connected together by nipples and the lower nipple *c* is attached to the water-supply pipe. A double-ring atmospheric burner *d* is supplied by a gas pipe *e*. The gas-cock for the burner *d* is located at *f*, while *g* is the pilot-light cock. The sheet-metal cylindrical casing *h* is shown raised over the flow pipe; this shows how easily the heater can be inspected and cleaned. The hole *i* is for the pilot light, which when lighted throws a long, thin flame through this hole and over the atmospheric burner. To start the heater, the pilot light is ignited first; the gas is then turned on to the ring burner, and as soon as this is lighted, the pilot light is shut off.

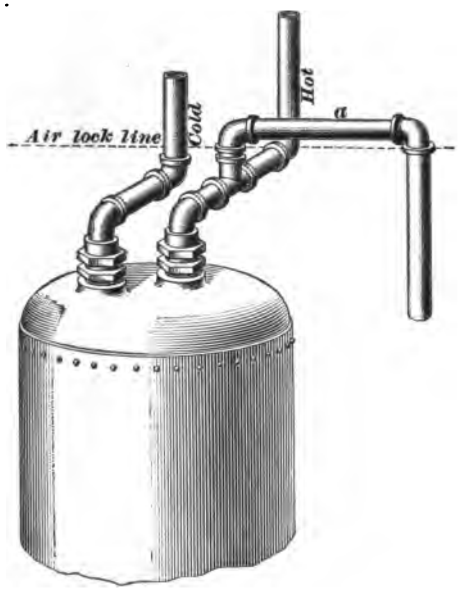


FIG. 17

In some cases, thermostats are set in the boiler and connected by the gas-supply cock to the heater, in order that when the temperature of the water in the boiler reaches a certain point, the gas will be automatically turned down, being turned on again automatically when the temperature begins to drop.

**35. Boiler-Heater Connections.**—Gas water heaters will not give satisfaction when they are wrongly connected. They should not be connected to the side tapping of a boiler, because the entire boiler must then be heated before hot water can be

drawn from the hot-water faucets. The proper place to make the connection is on top of the boiler to the hot-water pipe, as shown in Fig. 15. The connection must never be made as shown in Fig. 17. An air lock is formed at *a* and the heater is *air bound.* The air liberated from the water while it is being heated will accumulate in the pipe *a*, even though drawn off periodically by a petcock, and will prevent a circulation between the heater and the boiler. The heater will generate steam and produce a disagreeable noise by water hammer. The principal object in connecting the heater to the top of the boiler is to give hot water at the faucets before the boiler is warm.

**36.** The mud or sediment that naturally gathers in the bottom of the boiler must be prevented from choking the lower or return pipe to the heater. A chokage here will prevent circulation and thus produce water hammer in the heater by the generation of steam. A sediment cock must therefore be provided to allow the boiler and heater to be blown off; that is, emptied, occasionally.

Stop-cocks and valves should never be placed on the circulation pipes between a gas heater and a boiler, or between a range waterfront and a boiler, because some person through ignorance may close these valves while the gas is burning in the heater and thus cause an explosion.

Gas water heaters for boilers should preferably be provided with a flue connection to a chimney to carry off the gases of combustion. This provision should always be made where the ventilation of the kitchen is poor, as usually is the case in city houses.

**37. Boiler-Heater Troubles.**—The chief trouble experienced in the use of water heaters is due to the accumulation of soot and lampblack caused by the burner being allowed to blow back and burn in that way for some time. The soot forms an insulating covering on the heating surfaces, which prevents the water from being heated properly. To remedy this, the inside of the heater must be thoroughly cleaned and the air mixer adjusted to admit the proper proportion of air to the gas. Heaters should never be lighted unless the water is free to

circulate through them, for if the water does not circulate freely, the extreme heat may burn or warp the parts and thus cause the heater to leak.

There is usually a small amount of drip from water heaters, even when all water connections are tight. It comes from the water vapor, produced in the combustion of the gas, which

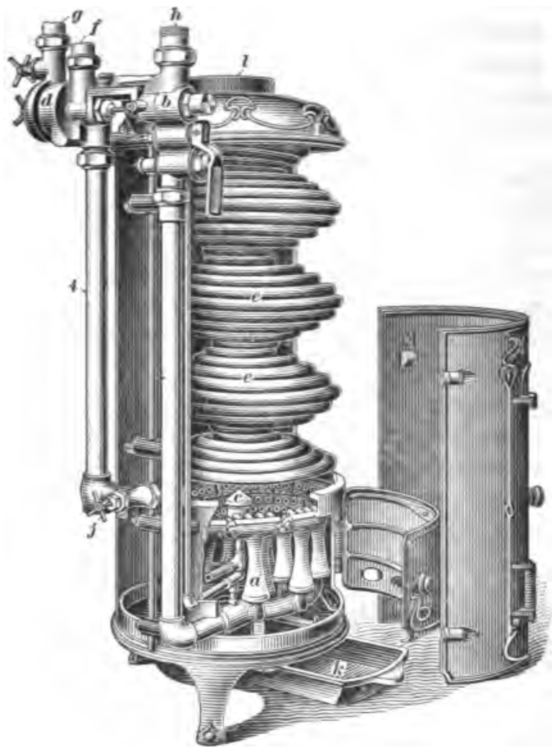


FIG. 18

is condensed by the cool surfaces of the heater when the water has not yet been raised to near the boiling point. Small pans are often provided to catch this drip.

**38. Closed Instantaneous Water Heaters.**—Automatic instantaneous heaters in which the water does not come in contact with the products of combustion are designed to take

the place of both heater and boiler. Such heaters consist of one or more very large burners under a water coil or casting having a very large surface exposed to the heat. They are usually placed in the cellar, and the hot-water pipes run from them to all parts of the house, just as from an ordinary house boiler. A valve is placed in the cold-water inlet pipe of the heater and so connected to another valve on the gas-supply pipe that when a hot-water faucet is turned on in any part of the house, the gas is automatically turned on at the heater by the opening of the cold-water valve there.

**39.** Fig. 18 shows a heater of this type with casing removed. The atmospheric burners *a* are supplied with gas through an automatic gas valve *b*; the pilot light *c* is allowed to burn all the time. Cold water enters the heater through a special automatic valve *d*, flows through the heating coil *e*, over which the flames from the burners play, becomes heated, leaves the heater through *f*, and flows to the open faucet; *g* is a cold-water supply and *h* is the gas supply to the heater. The holder *i* contains the thermostat that automatically controls the temperature of the water. The valve *j* is used for draining the water from the heater coil, and the removable drip pan *k* catches any water of condensation. The pipe connection for removing the gas fumes to the chimney is shown at *l*.

**40.** The form of heater illustrated in Fig. 18 can be used to supply a number of hot-water faucets located throughout a building. The nearer it is placed to the faucets the quicker will the hot water be drawn, for with a faucet set a long distance from the heater considerable time is spent in waiting for the cold water to be drawn from the line before the hot water reaches the faucet.

The proportions of the burner and heating surface are such that the water is heated nearly to the boiling point as fast as it goes through the heater. As soon as enough hot water has been drawn, the faucet is closed. The water pressure in the house pipe at once rises to that of the street mains, and the water valve on the heater closes and the gas valve is shut off at the same time. These heaters, while they burn a large

amount of gas when in operation, are very economical because no gas other than the small amount used in the pilot light is burned when hot water is not actually being used. The gas-supply pipe for such a heater should never be smaller than $1\frac{1}{4}$ inches, and a connection to the chimney should always be

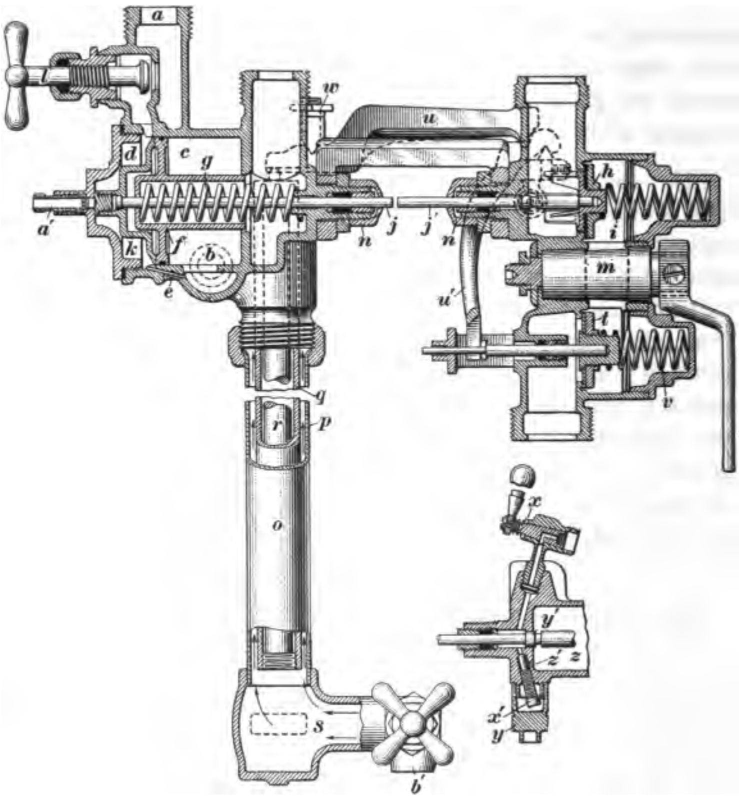



Fig. 19

provided to carry off the products of combustion. At least a 20-light meter should be employed to measure the gas used by the heater.

**41.** The automatic gas and water valves illustrated at *b* and *d*, Fig. 18, are shown in section in Fig. 19. The end *a* is screwed to the cold-water supply pipe, and the tapping *b* is

connected to the top inlet of the heating coil. When no water is being drawn from the hot-water faucet, the water pressure in space *c* is equal to that in space *d*, because a small tube *e* allows the pressure to equalize. But when the hot-water faucet is open, the pressure falls in *c* and the pressure in *d* instantly moves the back plate *k* and piston *f* against the pressure of the spring *g*; it also opens gas valve *h*, which is held tight by the spring *i*, the movement between the two valves being transmitted by the rods *j* and *j'*. The gas then flows freely through the gas valve to the burners in the heater, where it instantly becomes ignited by the pilot light. When the hot-water faucet is shut off, this action will be reversed and the valve will return to the position shown.

The water-valve piston *f* has a loosely fitted plate *k*, to which the rod *j* that works the gas valve *h* is attached. If the piston *f* should stick and fail to return to the proper position when the water is shut off, the equalizing of the pressure in the space *c* with that in *d*, will cause plate *k* to be pushed back by the spring *i* and thereby allow the gas supply to be shut off. This condition will allow cold water to by-pass through the water valve when the hot-water faucet is open, without turning on the gas; this action will continue until the sediment is removed. If the valve was otherwise constructed, an unnecessary amount of gas might be consumed. The valve *l* is adjusted to regulate the flow of water so that no more water will pass through the heater than it is able to heat properly. The gas-cock *m* is the main shut-off valve to the burners. Stuffingboxes *n* make a water- and gas-tight joint around the stem *j*.

**42.** The control of the temperature of the water through the heater is maintained by the thermostat *o*, which is composed of a casing *p* that encloses a copper expansion tube *q*, which in turn contains a solid porcelain rod *r*. The copper expansion tube is securely fastened at the top but the other end is free to move. Hot water from the heating coils flows through *s* and the space between the copper tube *q* and the casing *p*, as shown by the arrows. The contact of the hot water with the copper tube *q* causes the tube to expand. As there

is practically no expansive movement in the porcelain rod, its top moves with the expansive movement of the copper tube *q*, and this motion is transmitted to the gas valve *t* by means of the levers *u* and *u'*, which with the aid of the spring *v* regulate the gas supply when the water has attained the temperature desired. The temperature of the water at which the thermostat opens and closes the thermal valve *t* is determined by regulating the adjusting screw *w*.

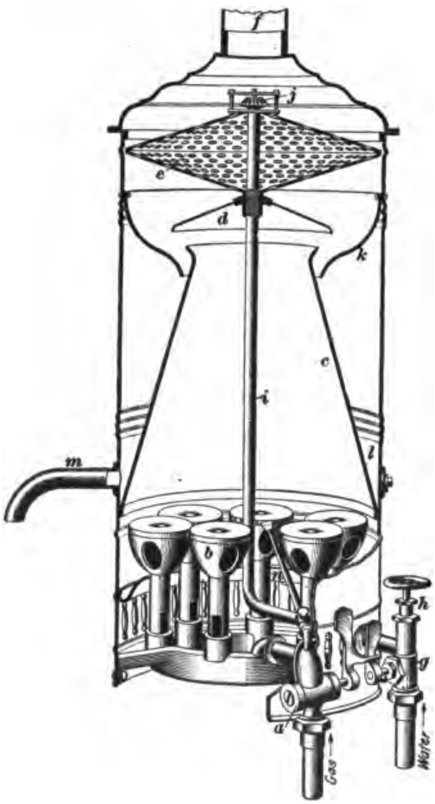



Fig. 20

The gas-cock *x* shuts off the gas from the pilot burner. A needle valve for regulating the flow of gas to the pilot is shown at *x'*. The cap *y* protects the needle valve and when removed can be reversed and used as a wrench for regulating the valve. The ground flange *y'* on the gas-valve stem is forced from its seat when the hot-water faucet is opened, allowing the gas in chamber *z* to pass around the smaller part of the stem, which will then be in the center of the opening, to the pilot tube through the valve *x*. The gas supply to the pilot while the hot-water faucet is closed is through the small port *z'*, then through the passage regulated by the needle valve *x'* and across the stem chamber and through the pilot shut-off valve *x* to the pilot, the object of the by-pass being to flash the pilot light an instant before the gas is admitted to the

main burners, the size of the flash being regulated by the needle valve $x'$. The plug $a'$ is an air vent to allow the water to drain from the thermostat when the drain $b$ is opened.

**43. Open Instantaneous Water Heater.**—Low-pressure automatic instantaneous water heaters may be constructed in different ways, a popular form being that in which the water comes in contact with the products of combustion. Such heaters are designed for use in bathrooms, etc., where the water is used at once and for external purposes only. Fig. 20 shows a heater of this type. It is composed of an outer casing, a set of atmospheric burners at the base, and specially arranged heating plates, both perforated and plain. The water flows over one side of the plates, while the flame and hot gases come in contact with the other side; hence, the water is quickly heated as it flows toward the outlet nozzle. Gas flows to the heater through a valve *a*, feeds the burners *b*, and heats the internal plates *c*, *d*, and *e*. The flames strike directly against the surface of *c*; the gases of combustion impinge against the under side of the thin bell *d*. Their course is then diverted, and the gases rise through the perforations in the plates forming the chamber *e*, escaping to the chimney through a vent flue *f*. Water enters the heater through the valve *g*, which is hooked to the gas valve in such a manner that when the gas valve *a* is open the water valve must also be open. The heater is thus prevented from being lighted while the water is not flowing through it, which avoids the burning of the plates, which are very thin. The water valve *g* is furnished with a checking-down valve *h* by which the flow can be regulated to that best adapted for the successful operation of the heater.

When the gas-cock is turned on, the cold water immediately flows through the tube *i*, and is distributed by the spreader at *j* over the upper surface of the upper perforated plate of the chamber *e*. The water then percolates through the perforations at the top and bottom of *e*, and falls by gravity on the top of the bell *d*, from which it flows into the funnel *k*, which guides it against the upper neck of *c*. The water then

runs down in a thin sheet over the outer surface of *c* to the water-collecting chamber *l*, from which it flows by gravity, quite hot, through the outlet nozzle *m* that projects over the fixture to be supplied with hot water. The tube *n* supplies a small pilot light in the center of the burners, which is used to ignite them and may burn all the time. Since this is an open heater, and hence cannot be used under pressure, it must always be located above the fixture to be supplied with hot water. This type of heater is the most economical in the use of gas, but it has the disadvantage of being unable to supply more than one or two fixtures, which must be close together.

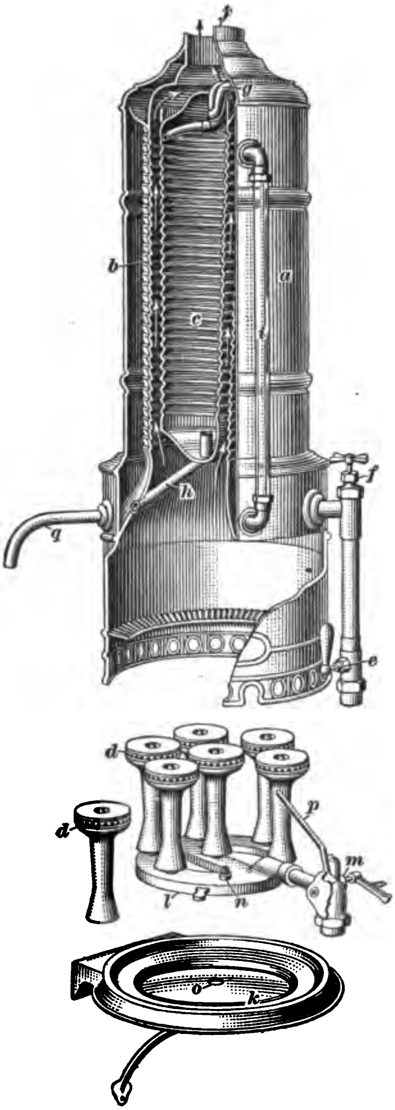


FIG. 21

**44. Non-Contact Instantaneous Water Heater.**—A special form of heater that does not employ a boiler or other storage reservoir is used for heating small quantities of water to the boiling point in the least possible time. The heater is usually placed in the kitchen over the sink, or at the bathtub or bowl where the hot water is required. It is called non-contact because

the products of combustion do not come in contact with the water. Owing to the rapidity with which heaters of this kind will heat water, they have been given the name of instantaneous water heaters. Their interior construction is shown in Fig. 21.

The heater consists of an outer nickel-plated casing *a*, corrugated copper cylinders *b* and *c* so arranged that the hot gases from the burners *d* may pass between them, as shown by arrows, thereby heating the water instantaneously. The water is supplied through a supply valve *e* and the water-regulating valve *f*, whence it passes up through a pipe to *g*, where it flows over the spirally corrugated copper cylinders. The tube *h* connects the water space or inside of *c* with the water space outside of *b*. A water glass *i* is used to determine the height of the water in the heater. The vent *j* should be connected to a chimney. The heater is set on an enameled shelf *k*, to which the gas ring *l* and valve *m* are attached. The gas ring is provided with a number of gas nozzles *n* on which the burners *d* are placed. The small opening *o* is for a $\frac{3}{8}$-inch pipe connection to carry off water of condensation.

**45.** The operation of the heater is as follows: First the pilot tube *p* is lighted, then the main water and gas valves are simultaneously turned on; the water will then flow to the top of the heater, down over the corrugated surfaces *b* and *c* in thin sheets, and out of the spout *q* to the fixture to be supplied with water. The temperature of the water is regulated by the valve *f*, no more water being allowed to enter the heater than can be heated to the desired temperature.

**46.** A $\frac{3}{4}$-inch gas-supply pipe, if short, should be run to the heater. If longer than 25 feet, a 1-inch pipe should be used if the gas pressure is 2 inches or less. A flue connection should be made in all cases, as the products of combustion generated by such a large consumption of gas in a room the size of the ordinary bathroom renders it dangerous to use the heater without a flue pipe. In common with all other gas appliances having large chambers in which gas may accumulate,

these heaters are liable to explode if the gas is turned on for some time before it is lighted.

Generally, these heaters are set on a shelf in the bathroom between the bath and basin. One outlet may then be made to the bath and another outlet to the basin, a valve being placed on the nozzle that delivers water to the bath and a gooseneck bend on the nozzle that delivers water to the basin. Then, if the bath valve is open, the hot water will flow to the bath only. If the bath valve is closed, the water will rise in the chamber *l* until it overflows through the gooseneck to the basin.

# PLUMBING TOOLS AND MATERIALS
(PART 1)

## DUTIES AND RESPONSIBILITIES OF A PLUMBER

**1.** The plumbing of a building includes the pipes, tanks, drains, and fixtures necessary for supplying both hot and cold water to the building, and for the removal of sewage therefrom. It is the duty of the plumber to install the equipment necessary for such work.

The plumber who wishes to take a prominent position in the plumbing business must know more than how to use plumbers' tools, wipe a joint, and connect iron pipes. He must also understand the principles underlying the installation and operation of the different apparatus and fixtures with which modern buildings are equipped, so that he may be sure that whatever equipment is necessary for the convenience and health of the occupants of the building is properly installed. This requires a considerable amount of knowledge in regard to the subjects of sanitation, water purification, ventilation, and the laws governing the movement of water and air in pipes.

The need of plumbing in the home is perhaps more universally recognized in the United States than elsewhere, and this fact has resulted in a varied output of fixtures, supplies, and materials by the manufacturers, and a high degree of skill on the part of the plumber who installs them and keeps them in order. If he uses improper materials, wrong methods of installation, or bad workmanship, sewer gas or sewage may escape

into the house, and cause illness or even death of the occupants, whose safety has been entrusted into his hands.

The owner of the building, who seldom has any knowledge of the requirements of good plumbing, depends for his comfort and safety entirely on the integrity and skill of the plumber, and a workman who would knowingly neglect to observe the proper precautions to safeguard the health of the occupants of a building is little less than criminal.

**2. Advice for Beginners in Plumbing.**—When starting in the plumbing business, the first lesson that a young man should learn is to be polite, agreeable, and good-natured with every one with whom he comes in contact. He must learn to obey orders even though they may sometimes be disagreeable. He should learn the names and uses of tools and should watch the progress of the work so as to have the right tool at hand when it is needed. Thus, if a lead pipe is to be cut, the pipe-cutter or a saw will be needed first, a rasp for smoothing the ends, then the plug and hammer, and so on. The best helper is the one who anticipates the plumber's needs and provides for them. The apprentice who exhibits intelligence and tries to be of service, obtains the good-will of the plumber, who will be glad to teach him at every opportunity.

**3. Neatness in Work.**—Wherever the work may be, whether in the shop, on a new building, or in a home, the work should be done with the least possible disturbance or soiling of the surroundings. All refuse from the work should be removed, and, especially in homes or furnished buildings, care should be taken not to leave dirty finger-marks or scratches on the walls or furniture. It is advisable to carry in the tool kit a pair of woolen stocking feet or felt moccasins that can be drawn over the shoes when it is necessary to work on or walk over highly polished floors. Such care marks the finished workman and creates a good impression on the customer.

## PLUMBING TOOLS

**4. Tools Required.**—A plumber must have proper tools in order to do good work and the apprentice should begin at once to accumulate a kit by buying a few tools at a time. He can thus get the best, and the cost will not seem so great as if the whole kit were purchased at once. As soon as he has tools, he can practice using them during his leisure moments. Plumbers differ in their choice of tools, but those that are in common use will be here described.

FIG. 1

**5. Tool Box.**—One of the first articles to be made or bought is a substantial tool box, one form of which is shown in Fig. 1. The tool box should be about 42 inches long, 20 inches wide, and 19 inches deep, and should have one or two detachable drawers for the smaller tools, such as bits, chisels, etc. A box of this size is large enough so that when taken onto a job it will hold all the tools commonly used, including stocks, cutters, etc.

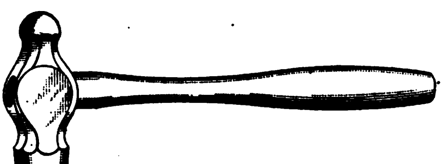


FIG. 2

**6. Commonly Used Tools.**—The first tools the apprentice will find use for are a rule, hammer, chisel, screwdriver, a 10-, 14-, and 18-inch Stillson wrench, combination pliers, brace and bits, and saws.

Fig. 2 shows a good type of *hammer,* which for ordinary use should weigh 1 to $1\frac{1}{2}$ pounds. A hammer weighing $2\frac{1}{2}$ or 3 pounds is also needed for such work as cutting heavy soil pipe or for drilling holes in walls. Fig. 3 shows a form of *extension rule,* which can be obtained in convenient lengths. Fig. 4 shows a *screwdriver,* which for plumbers' use has the steel extending through the handle.

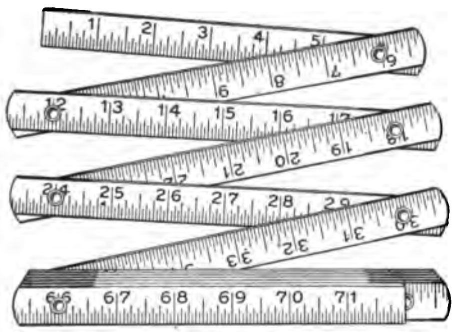


FIG. 3

Fig. 5 shows three forms of chisels; in (*a*) is shown a *cold chisel,* used chiefly for cutting cast-iron pipe, brick, and stone. A *cape chisel,* shown in (*b*), is similar to a cold chisel but is narrower at the cutting edge, being only about $\frac{1}{4}$ inch wide; it is used for cutting holes in cast-iron pipe, or brick or stone. In (*c*) is shown a *floor chisel,* which is very similar to a cold chisel with a wide, thin face or cutting edge; it is useful for cutting the tongue of floor boards so that they can be raised without material damage to the floor.

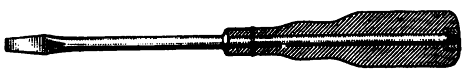


FIG. 4

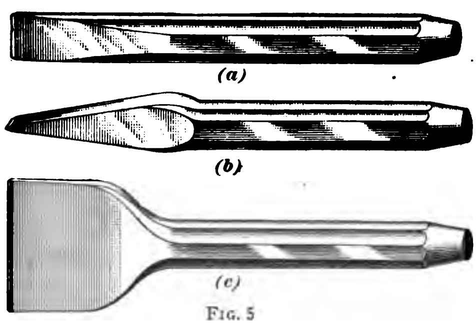



FIG. 5

**7. Wrenches.** *A Stillson wrench,* Fig. 6 (*a*), is used for gripping and turning iron pipe, bolts, or anything of cylindrical form. The jaws of such a wrench have teeth that bite into the pipe and hold firmly. There are other forms of pipe wrenches, but the Stillson is most commonly used.

A *monkeywrench,* Fig. 6 (*b*), is chiefly used for tightening or loosening bolts, nuts, couplings, etc., where a Stillson or similar toothed wrench should not be used.

The *S wrench,* Fig. 6 (*c*), is used for the same purposes as the monkeywrench; it is convenient for use in places that cannot be reached by a monkeywrench.

The *strap wrench,* Fig. 7 (*a*), is intended for use on nickel-plated or brass pipes or anything that must not be marked with the teeth of a Stillson wrench. A little powdered rosin shaken

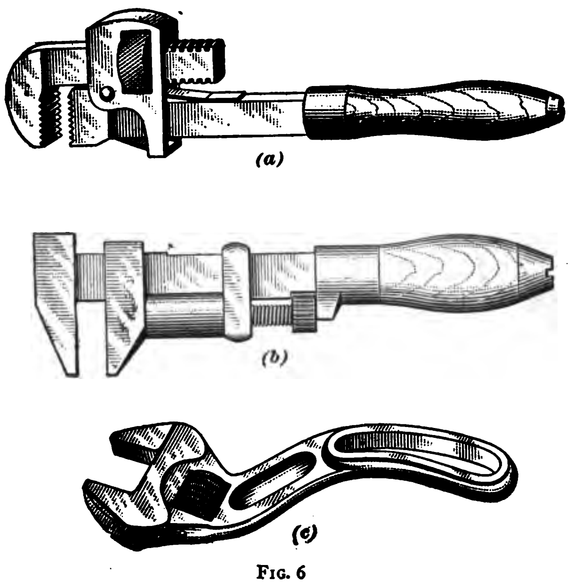


FIG. 6

on the strap *a* helps to prevent its slipping when in use. The wrench shown in (*b*) is a *friction wrench* and is used the same as the strap wrench. It is made of forged steel and has removable clamps *a* having a hinge at *b* and corresponding to the standard sizes of iron pipe. Separate clamps are required for each size of pipe.

A *pipe wrench,* or *chain tongs,* shown in Fig. 7 (*c*), is used for turning up or unscrewing the larger sizes of pipe. It has a handle *a* with parallel-toothed jaws *b* and a chain *c,* one end of which is fastened and the other loose so that it can be put

around the pipe. The links of the loose end can be dropped into slots between the jaws *b*, thus holding the chain firmly, and the greater the strain on it the tighter it and the toothed jaws grip the pipe.

**8.** Many special forms of wrenches are made for use on various kinds of fixtures. The ***basin-plug wrench***, Fig. 8 (*a*), is used to hold the waste plug of a basin while it is being

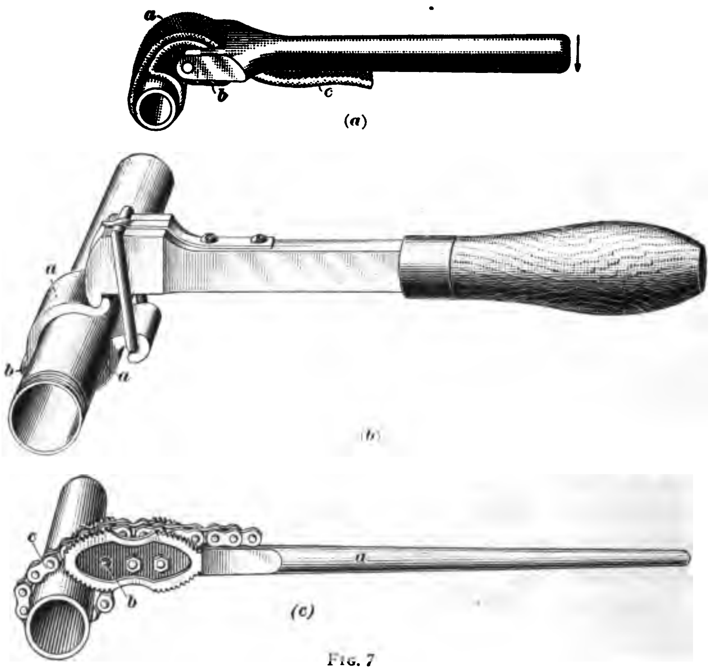



FIG. 7

tightened from beneath the bowl. The ***basin-cock wrench***, shown in (*b*), is used to tighten couplings and locknuts under wash basins. The jaws *a* are adjusted to fit the coupling by moving the connecting bar *b* up or down as required and are tightened with the thumbscrew *c*. The ***closet-spud wrench*** is shown in Fig. 8 (*c*). By its use the closet spud can be held perfectly rigid when the connection is being taken off and thus the danger that the spud will turn and cause a leak is avoided. Without such a wrench, this is difficult to do.

**9. Pliers.**—The *combination pliers*, Fig. 9 (*a*), is a handy tool for which the plumber finds many uses. The 6- or

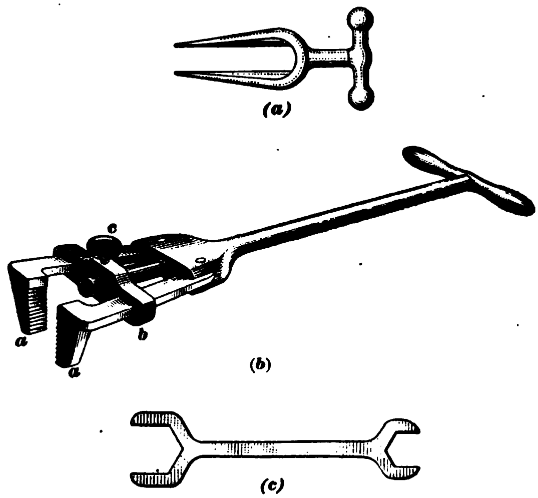



FIG. 8

8-inch size is convenient to carry in the pocket, and larger sizes are also manufactured. Other forms of pliers are the *straight combination pliers* shown in Fig. 9 (*b*) and the *bent-nose pliers* shown in (*c*). The bent-nose pliers are used to advantage under a basin or behind a tub where the connections are close.

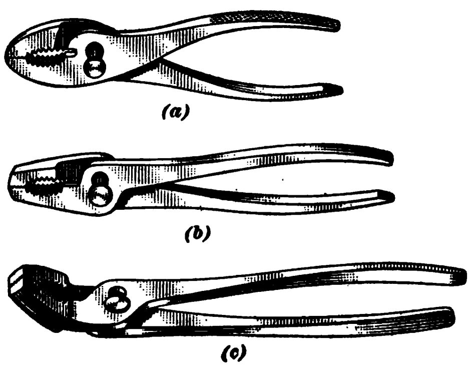



FIG. 9

**10. Brace and Bits.**—Fig. 10 shows a *ratchet brace* used for boring holes with a bit. When necessary, movement of a latch brings the ratchet into action and thus permits the boring of holes in corners or near walls where otherwise a brace could not be used

In Fig. 11 are shown a number of forms of bits for use with a brace. In (*a*) is an *expansion bit,* which can be adjusted

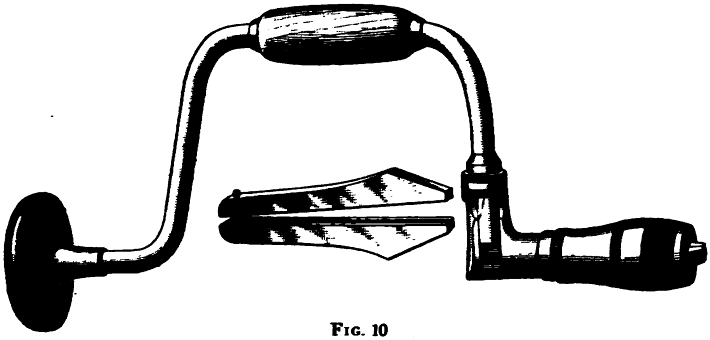


FIG. 10

to bore holes of several sizes; in (*b*) is shown a *feeling bit* used for boring holes through a ceiling or similar construction; this bit comes out on the other side and locates the position of the hole and, on account of its size, does little damage if the hole comes through in the wrong place. An *extension bit holder,* shown in (*c*), is used to lengthen the bit when the space, as between a floor and the ceiling beneath, is too deep to

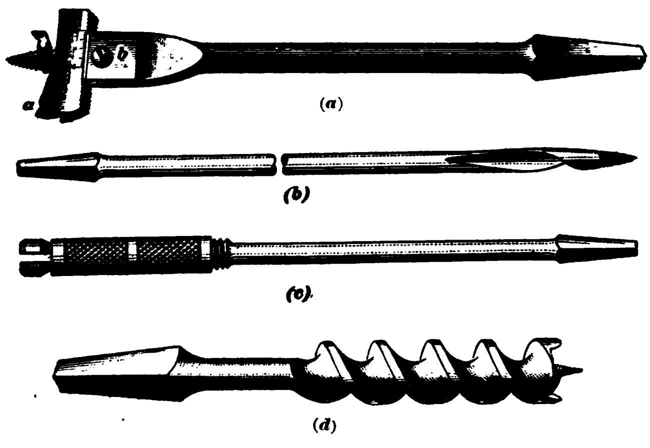



FIG. 11

be reached through by an ordinary bit. A common *auger bit* is shown in (*d*).

**11. Saws.**—Different forms of saws are shown in Fig. 12. In (*a*) is a *combination saw* that can be used for cutting lead

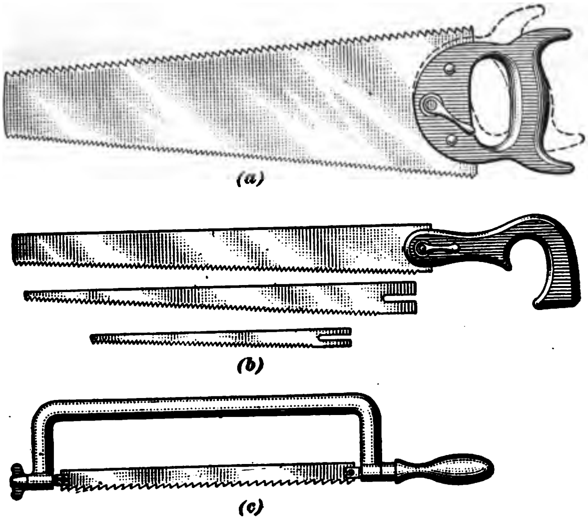


FIG. 12

pipe or wood. The blade is about 16 inches long and has coarse teeth on one edge and fine ones on the other. The handle can be adjusted as indicated by the dotted lines for use of either side.

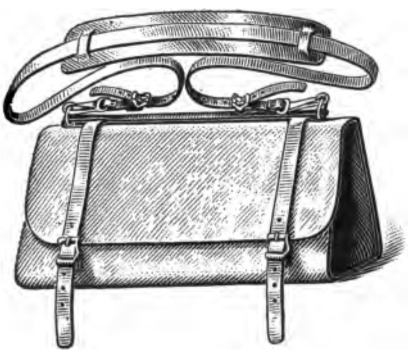


FIG. 13

In Fig. 12 (*b*) is shown a *compass saw* with extra different-shape blades that can be used in the same handle. Such a saw is used for cutting circular or irregular-shape holes often begun from a hole bored with a bit.

The *hacksaw,* Fig. 12 (*c*), which has a blade of special hard steel and has very fine teeth, is used for cutting brass and iron pipe, bars, bolts, etc.

**12. Tool Bag.**—For carrying a few tools, a *tool bag,* Fig. 13, is used. Some plumbers prefer a tool bag made of

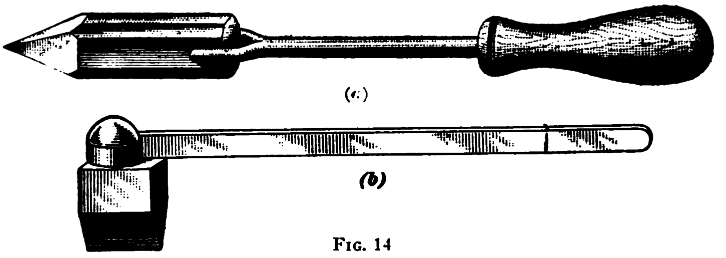



Fig. 14

carpet or heavy cloth with pockets for the different tools. This can be unrolled and the tools needed are easily picked out.

**13. Lead-Working Tools.**—Two forms of soldering bits are shown in Fig. 14; that in $(a)$ is called a *straight bit,* and that in $(b)$ is known as a *hatchet bit.* Each consists of a block of pure copper, shaped and fitted to a short iron rod, which may have a wooden handle, as in $(a)$, or be used without, as shown in $(b)$.

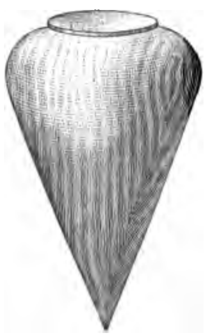


Fig. 15

**14.** The *plug,* or *turn pin,* shown in Fig. 15, is used for expanding the ends of lead pipe; it is convenient to have one for use on large pipe and another for smaller pipe. Fig. 16 shows a *dresser* made of boxwood and used for dressing and working sheet lead, lead-pipe bends, etc.

**15.** A *tap borer,* used for boring holes in lead pipe or bends, for the purpose of attaching other pipe, is shown in Fig. 17. The *bending iron,* shown in Fig. 18, is used for straightening lead pipe close to the end or for expanding holes made by a tap borer.

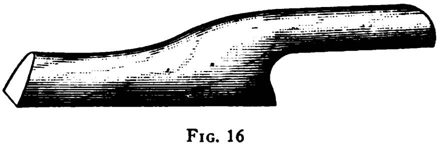


Fig. 16

A *shave hook,* used for cleaning lead pipe or sheet lead preparatory to soldering, is shown in Fig. 19. It has a strong

handle to which is attached a steel blade. These blades are made in various shapes, as shown, with the edges beveled.

The *dummy*, shown in Fig. 20, is used for dressing kinks out of bends or large lead pipe, from the inside. It consists of an iron handle on which a knob of iron or lead is securely fastened so that it cannot come off and fall in the pipe.

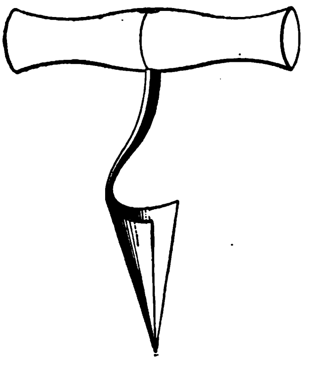


FIG. 17

The *drift plug*, shown in Fig. 21, is chiefly used for taking kinks out of lead waste pipe. Drift plugs are made in sets of different sizes.

**16.** *Pipe benders* are shown in Fig. 22. Such benders are inserted in lead pipe to keep the pipe from collapsing while being bent; they are made in sizes to correspond to ordinary waste pipe. The common form of bender shown in (*a*) is a spiral steel spring rounded at one end and having a hook or ring at the other with which to pull it out. The one shown in (*b*) is of similar construction, but has a connection on one end by which it can be screwed to a piece of iron pipe of such length that the bender can be inserted far enough into a lead pipe so that a bend can be made at a considerable distance from the end. The bender should be rubbed with tallow or grease before insertion so that it can be easily withdrawn.

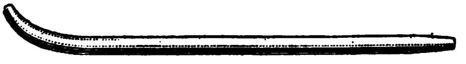


FIG. 18

**17.** Where lead pipe is much used, a *lead-pipe cutter*, Fig. 23, is an important tool, as it makes a smooth cut with no chips or dust. This is an advantage, as when a pipe is cut with a saw lead sawdust gets into the pipe and makes trouble at the seats of faucets or valves.

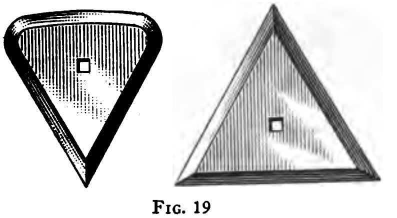


FIG. 19

The *chipping knife,* shown in Fig. 24, is used for cutting heavy sheet lead and the edges of lead pipe and is useful for many purposes on lead work.

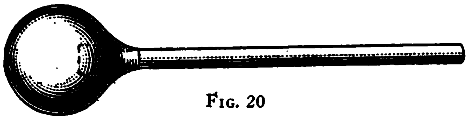


Fig. 20

**18.** *Dividers,* or *compasses,* shown in Fig. 25, are used to scribe arcs and circles, to divide circumferences or other distances, and for marking a line parallel to an edge to indicate how far lead should be shaved off for joints, etc.

Fig. 21

**19.** A *rasp* and *files* are shown in Fig. 26. The rasp, shown in (*a*), is used by plumbers for beveling sheet lead and for taking the edge off lead pipe when preparing it for a wiped or a soldered joint. The 12-inch size is convenient and a fine and a coarse one are required. Files for general purposes are a half-

(*a*)

(*b*)

Fig. 22

round file, shown in (*b*); a rat-tail, or round, file, shown in (*c*); and a flat file, shown in (*d*); the latter is used for filing solder nipples, brass ferrules, etc.

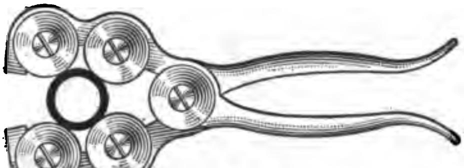


Fig. 23

**20.** A small *mirror,* or looking glass, that can be carried in the pocket or in a small case will be found convenient for looking behind boilers or under joints or floors.

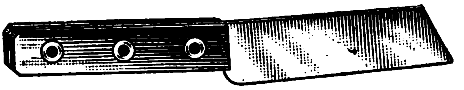


FIG. 24

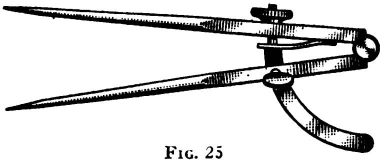
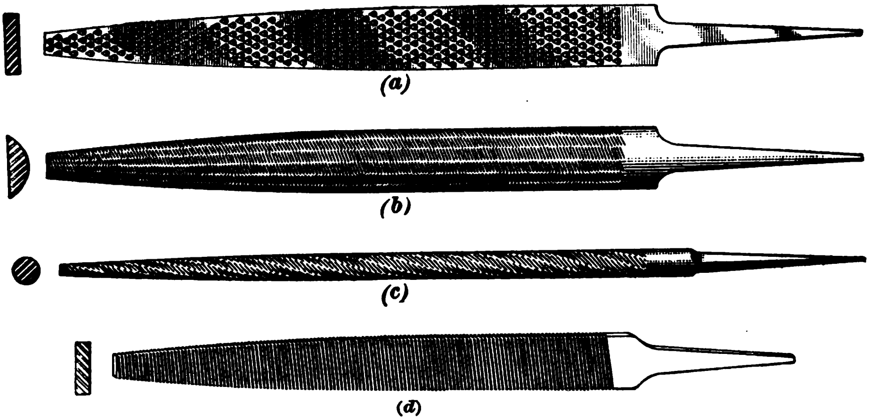


FIG. 25



(a)

(b)

(c)

(d)

FIG. 26

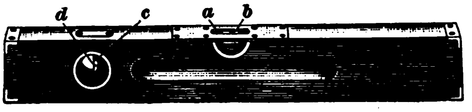



FIG. 27

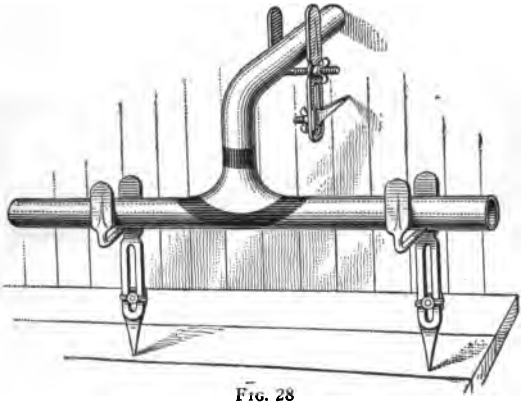


FIG. 28

**21.** The *level and plumb,* shown in Fig. 27, is an important instrument. With it the plumber determines whether or not pipes, fixtures, etc., are level or vertical. The instrument contains a small glass tube *a* partly filled with liquid so as to leave a bubble of air in the tube. When the level is laid on a perfectly horizontal surface the bubble *b* will be exactly at the middle of the tube. In the hole in the instrument is another glass tube *c,* placed at right angles to the edge of the level, so that when the instrument is placed in a vertical, or plumb, position, the bubble *d* will be in the middle of the tube.

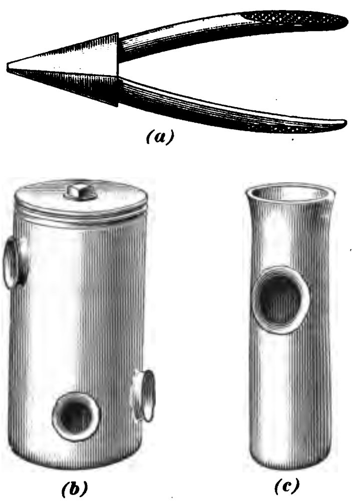


FIG. 29

**22.** The *lead-pipe clamps,* or *holders,* shown in Fig. 28, are convenient for holding lead pipes for joint wiping, and they save much time ordinarily consumed in improvising supports of bricks or wood.

**23.** *Expanding pliers,* shown in Fig. 29 (*a*), are useful for expanding holes tapped in lead pipe for the insertion of branches, etc. After the hole has been made with a tap borer, the conical end of the pliers is pushed into the hole, then turned back and forth while pressure on the handles tends to open the conical ends, make the hole larger, and form a collar around it.

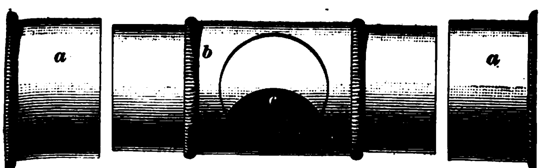


FIG. 30

An advantage of this tool is that it does not distort the pipe as a turn pin would. In (*b*) and (*c*) are shown holes in lead pipe that have been expanded with this tool.

**24.** A *grease and rosin box* is shown in Fig. 30. In this can be carried grease, rosin, and chalk. The end compartments are closed with caps *a*, and the middle one *c* by revolving the cylinder *b*.

FIG. 31

**25.** The *gasoline torch*, shown in Fig. 31, is commonly used by plumbers for maintaining heat in brass ferrules, large joints, and tank seams, while wiping, and for other purposes. It consists of a brass chamber, or body, *a* having a filling hole at *b*, which can be made air-tight by the brass screw plug shown. A pump *c*, which also serves as the handle to the torch, is used to pump up an air pressure in the tank. The small valve *d* prevents the air from forcing its way back into the pump when it is not in operation. The needle valve *e* adjusts the size of the flame, or shuts it off entirely.

**26.** A *fire-pot,* operated by gasoline and used for melting lead, solder, etc., is shown in Fig. 32. As gasoline is a highly volatile liquid, care must be taken in lighting fire-pots and torches to avoid danger of fire or explosion. A fire-pot should be lighted outside the building. The manufacturers of such apparatus furnish instructions for its operation and their directions should be followed.

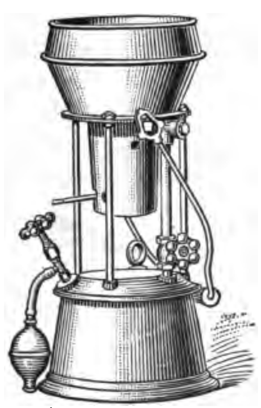


FIG. 32

In places where the use of gasoline is not allowed, fire-pots burning charcoal are used. One form of these is shown in Fig. 33. Care should be taken to have good ventilation in the place where such a fire-pot is used, as the gases given off by burning charcoal are extremely poisonous and have been known to cause the death of persons breathing them.

A *ladle,* such as shown in Fig. 34, is used to pour melted lead or solder when calking or wiping a joint. The three tips permit lead or solder to be poured from either side or end.

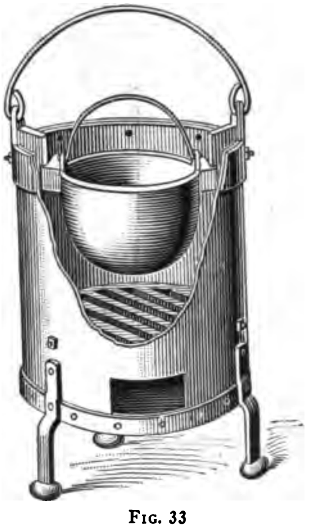


FIG. 33

The *solder* or *lead pot* shown in Fig. 35 is made of cast iron, and for ordinary jobs it should hold about 15 pounds of melted lead, but for big work a larger pot will be required. A *pot hook,* Fig. 36, is useful for carrying the pot into a ditch, up a ladder, or wherever it may be needed.

**27.** *Wiping cloths* are generally made of moleskin cloth or ticking, and are of various sizes. They may be made by the plumber or bought from dealers in plumbers' supplies. The sizes commonly used for joint wiping are given in Table I. Experience will show the size necessary for different kinds of work.

**28. Blowpipe.**—Plumbers are rarely called upon to do lead burning and for that reason they may not be warranted in purchasing a special lead-burning machine. In such cases the lead burning may be done with an air-and-gas compound blowpipe, which is convenient also for other work such as light brazing operations, ordinary illuminating gas being used for

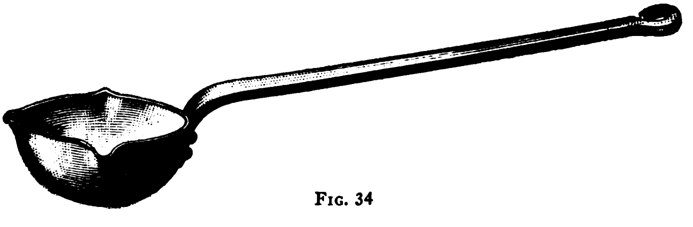


FIG. 34

the flame. Fig. 37 shows the Walmsley compound blowpipe. This tool enables plumbers to burn traps, bends, and the seams

in small tanks and sinks, by using illuminating gas for the flame and Yager's salts for the flux. The blowpipe when properly regulated burns with a non-oxidizing flame, of which the valve *a* gives perfect control. Two rubber tubes are necessarily attached to the blowpipe; the small one *b* is for air and the larger one *c* for gas. The holes shown in the side of the gas pipe *d* are for admitting air to the gas before it reaches the mouth of the blowpipe. The air pipe *e* when adjusted is clamped in position by the thumbscrew *f*. A nipple having a small opening is screwed over the nose of the air pipe at the mouth of the gas pipe. Different sizes of nipples are provided for different kinds of work and are interchangeable on the blowpipe. There are several sizes of these blowpipes, but that known as the No. 1 hand blowpipe is most convenient for plumbers and lead burners. The blast is furnished by blowing into the rubber tube *b*, which is placed in the mouth.

FIG. 35

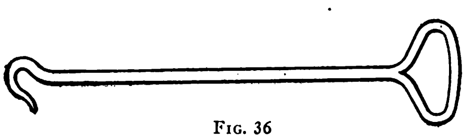


FIG. 36

**TABLE I**

**SIZES OF WIPING CLOTHS**

| Size of Pipe<br>Inches | Size of Cloth<br>Inches | Thickness of Cloth<br>Layers |
|---|---|---|
| $\frac{1}{2}$ | $3 \times 3$ | 6 |
| $\frac{1}{2}$ to $\frac{3}{4}$ | $3 \times 3\frac{1}{2}$ | 6 |
| 1 | $3\frac{1}{2} \times 4$ | 8 |
| $1\frac{1}{4}$ to $1\frac{1}{2}$ | $4 \times 4$ | 8 |
| 2 | $4 \times 4$ | 8 |
| 3 | $4 \times 4$ | 8 |
| 4 | $4 \times 4$ | 8 or 10 |

**29. Thawing Steamers.**—Every plumbing shop that is in a cold climate has need of apparatus for thawing frozen pipes that are underground or in places otherwise difficult of access. This can often be done by injecting steam into the frozen pipe through a small lead or block-tin tube connected to a steam generator called a thawing steamer.

Fig. 38 shows a thawing steamer that can be set on and heated by an ordinary plumber's fire-pot. Water is supplied to the boiler *a* though a combination funnel and safety valve *b*. The safety valve is used to allow steam to escape to the atmosphere if an excess of pressure is raised in the boiler, and should always be in working order. A valve *c*, to which is attached a small lead or block-tin tube *d*, conveys steam to the frozen pipe. When steam is up, the open end of the tube is pushed inside the frozen pipe until it strikes the ice, and steam is allowed to blow against the ice, thus melting it. This apparatus is very serviceable where the pipe is frozen for only a short distance.

FIG. 37

**30.** A more substantial type of thawing apparatus, in which higher steam pressures can be used, is shown in Fig. 39. It consists of a small upright tubular boiler with a firebox and grate, and is completely equipped with water-gauge glass, pressure gauge, gauge-cocks, safety valve, water-cocks, and drain cock. The thawing tube is connected at *a*. Water is supplied to the boiler, without letting off the pressure, by means of the apparatus shown at the left. This consists of a funnel *b* connected by a pipe to a receiver *c* made of a short piece of 6-inch pipe reduced at both ends and connected to the boiler as shown. When the valve *d* is closed and *e* is open, the receiver may be filled with water through the funnel; then, when valve *e* is closed and *d* is open, the water will flow by gravity into the boiler, since the receiver *c* is placed higher than the water level in the boiler. Water may thus be supplied to the boiler as needed.

When there is enough pressure in the boiler, the open end of the thawing tube is pushed into the frozen pipe until it comes in contact with the ice. The steam is then turned on, and as the ice melts the tube is pushed forwards until the pipe is completely thawed out. When the plumber feels the tube suddenly come toward him, he withdraws it quickly and carefully and closes the stop-cock or gate valve, which should always be put on the frozen pipe before beginning work if it is not there already.

If the work of thawing must be discontinued for any considerable length of time, the steam must be shut off and the thawing tube withdrawn; otherwise it may be frozen inside the water pipe. This would be a serious matter, especially if the water pipe were not large enough to allow the passage of another thawing tube. While the steam is on, the water produced by the condensation of the steam and the melting of the ice will be forced back past the thawing tube by the steam pressure,

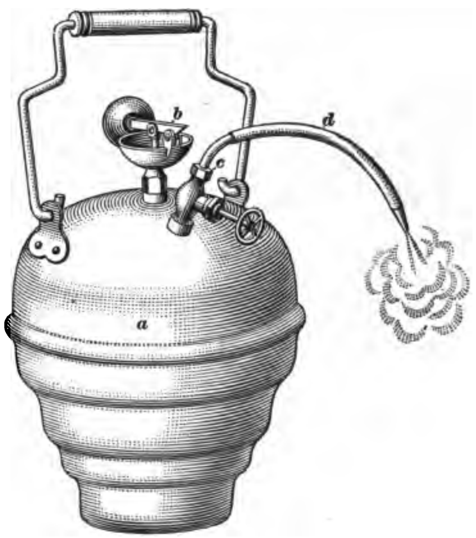


FIG. 38

but if the work is stopped before the pipe is completely thawed, all the water left in it must be removed or it will freeze and the work will have to be done over again. One means of removing the water is by the use of a suction pump, which can be attached to the end of the thawing tube after it has been disconnected from the steamer. Where the dip toward the main is not too heavy, the water can be sucked out with the mouth. The simplest means of determining whether the pipe is free of water is to blow through the thawing tube; if

air comes back freely through the water pipe, the water is all out.

**31. Tools for Working Iron Pipe.**—An asbestos *joint runner,* such as is used to retain melted lead in a joint, is shown in Fig. 40 (*a*). The runner in position on the pipe, ready to receive the molten lead, is shown in (*b*). A spring clamp, as shown, is used to hold the runner in position, and in (*c*) is shown a clamp that also serves as a pouring cup, which permits the lead to be poured more rapidly and to be more evenly distributed than can be done when the ordinary form of clamp is used. The asbestos runner is by far the best means of running a joint, and the old way of using clay or putty for this purpose should be discarded.

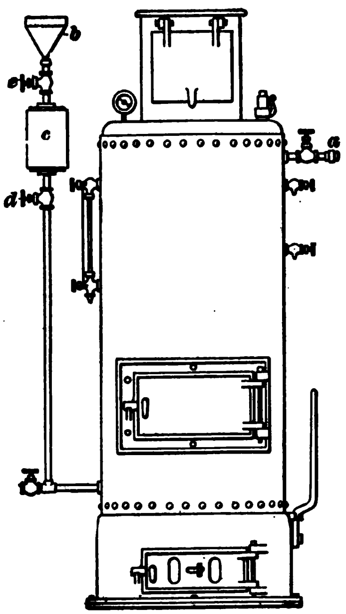


FIG. 39

**32.** A set of yarning and calking irons is shown in Fig. 41. There are many others forms of these tools, but for general purposes those here described will be sufficient.

In (*a*) is shown a *yarning tool* used for packing oakum into a joint to be calked. It is necessary that such work be done carefully so that no place is left for the lead to run through into the pipe when the joint is poured. A *medium iron,* shown in (*b*), is just a little thicker than that in (*a*) and is used for compressing oakum in a joint after it has been packed in by the yarning iron; in (*c*) is shown the *regular iron* with which the lead is calked after it has been poured into the joint. A *finishing iron,* shown in (*d*), is a little wider than that in (*c*), and is used to finish the edges, etc. after the joint is calked. The iron in (*e*) is used for calking joints on bends; where the joint is close to the ceiling an

iron such as shown in (*f*) is used. In (*g*) is shown a *yarning iron* for use when a joint is situated where it is hard to reach with a shorter iron; in (*h*) is shown a *cold chisel,* which is used for many purposes, as previously explained. A *right-hand calking iron* is shown in (*i*) and a *left-hand* one in (*j*); these are useful when working on a soil pipe that is in a corner or backed up against a partition; in (*k*) is shown a *stub iron* used for calking. A *picking-out chisel,* shown in (*l*), is useful for digging lead out of a joint that is to be melted out or taken apart. A *right-and-left calking iron,* shown in (*m*), is used to save carrying two irons like those in (*i*) and (*j*). A *brick chisel,* shown in (*n*), is used for cutting holes through brick walls.

Besides the calking tools here shown there are often included other tools, such as *gouges, diamond-point chisels, cape chisels, floor chisels, etc.,* some of which have already been described. It is important that all calking tools be made of the best of steel.

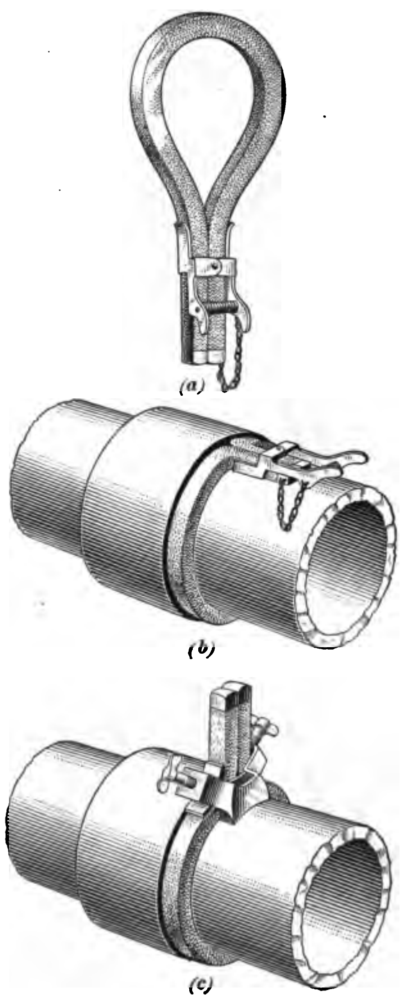



Fig. 40

**33.** *Pipe cutters,* such as shown in Fig. 42, are used for cutting wrought or steel pipe and soil pipe. In (*a*) is shown a three-wheel cutter, which is

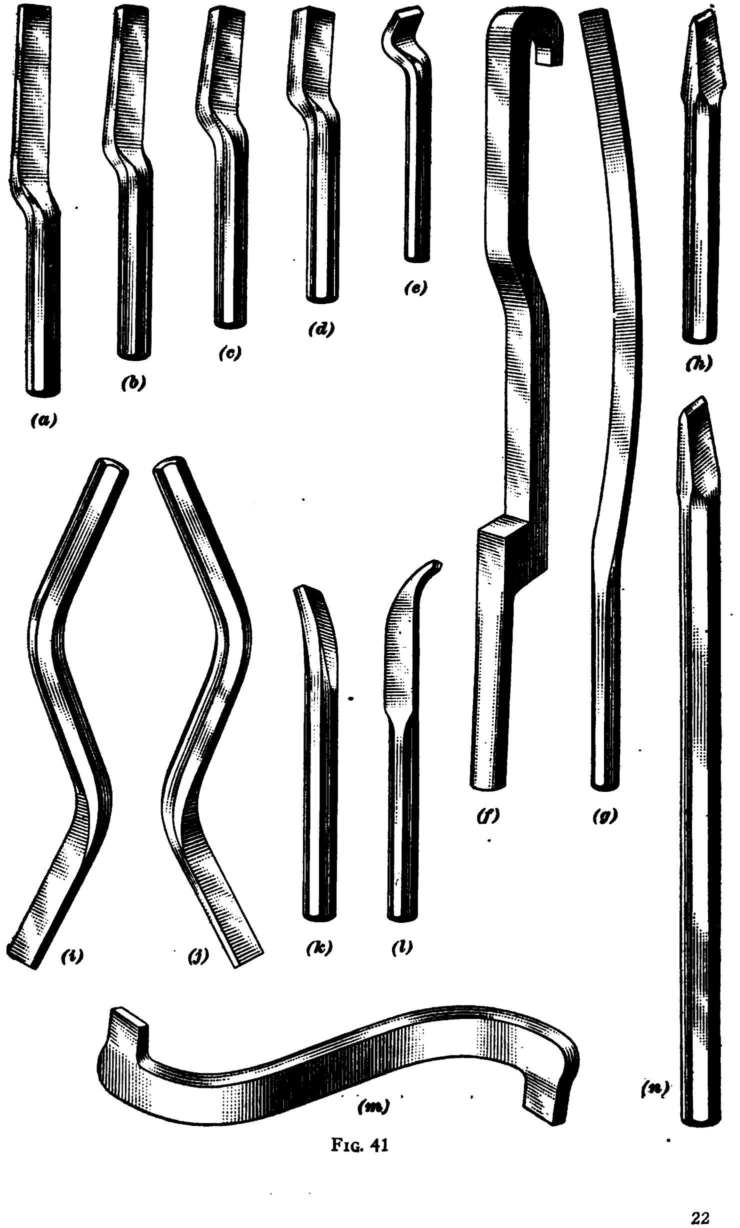



FIG. 41

made in various sizes and is used for cutting the smaller size pipe up to 2 inches diameter. The form shown in (*b*) works on the same principle as that in (*a*) and is used for the larger sizes of pipe. The cutter shown in (*c*) is especially for use on soil pipe. The old way of cutting a soil pipe around with a hammer and chisel and then breaking the pipe, is expensive and no longer necessary, as with the proper cutter the work

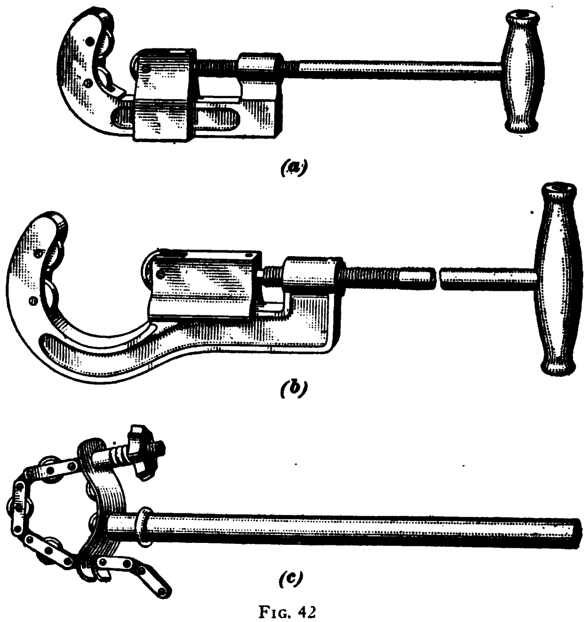


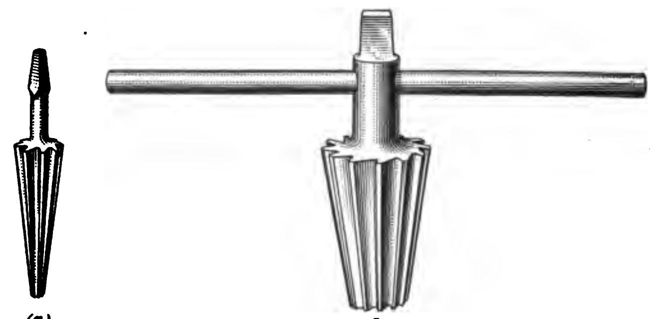
FIG. 42

can be done quickly and without injuring the pipe or disturbing it in any way.

**34.** *Pipe reamers,* shown in Fig. 43, are used to ream out the ends of pipe after it is cut, to avoid leaving a burr or raised rim on the inside of a pipe that would interfere with the passage of fluids. The reamer shown in (*a*) is for small sizes of iron pipe and is used in a brace; the one shown in (*b*) is for use on larger pipe.

**35.** *Stocks* and *dies,* shown in Fig. 44, are used for cutting threads over the ends of wrought and brass pipes. They

are made in various shapes and sizes. The dies shown in (*a*) and (*b*), and also shown in the sectional view, are those parts that, on being pressed against the plain end of the pipe and revolved by means of the stocks in which they are held, will take hold and cut a V-shaped screw thread over the end. Dies are either *solid* or *adjustable;* the solid die is generally used only for small pipes, and the adjustable die for the larger ones. Two forms of solid dies commonly used are shown in the illustration. The die in view (*a*) is made of one piece of tool steel having four sets of cutting edges; the die shown in (*b*) is made of malleable iron except the teeth, or chasers, which are of tool steel and set in the malleable-



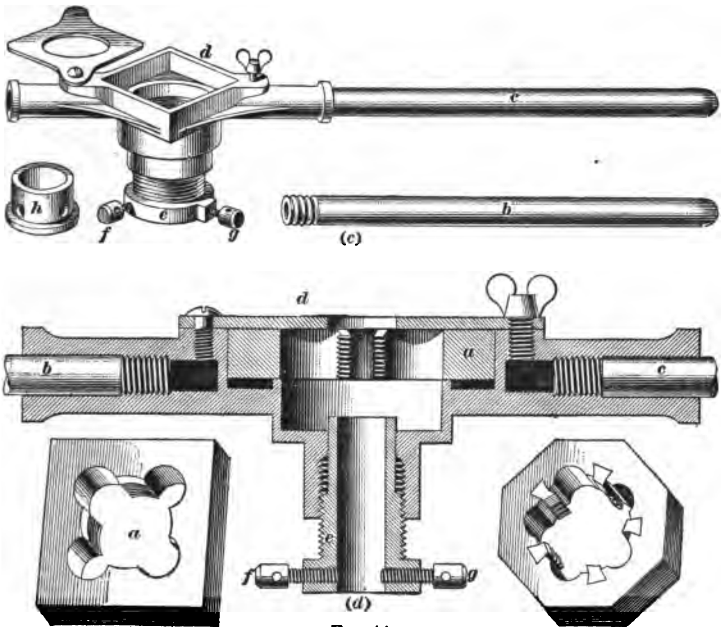
(a) (b)

Fig. 43

iron frame, as shown. This die admits the renewing of the teeth, or chasers, when they are worn, and is used for somewhat larger pipes than is the solid die.

Dies vary in thickness with the diameter of pipe to be threaded, being thinner for the smaller pipe. Solid dies cut the full depth of the thread by one operation, which wears them out rapidly, and on the larger sizes of pipes renders the cutting of a thread a very laborious task. To overcome these objections, the adjustable, or split, dies have been devised. These dies are composed of two or more parts so arranged that they can be opened or closed to cut a thread on a number of different sizes of pipe, also to cut out a little of the thread at a time or to cut a thread by a number of operations instead

of by one. Fig. 45 shows a means of holding four dies that can be adjusted in the manner explained.




(a) FIG. 44 (b)

**36.** The *die stock* shown in perspective in Fig. 44 (*c*), and in section in (*d*), is that part which holds the die solid and at right angles to the axis of the pipe on the end of which a thread is to be cut. It consists of two iron bars, or handles, *b* and *c* screwed into a malleable-iron casting *d*, in which the die *a* is placed, as shown in the sectional view. That part of the casting *d* that is slipped over the end of the pipe is supplied with a guide *e*, which moves in a threaded socket, the threads of which have

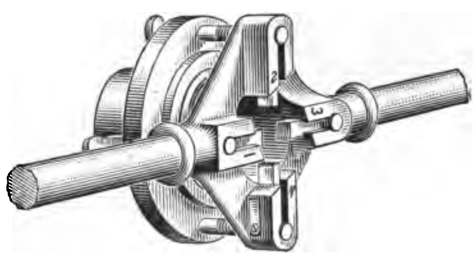


FIG. 45

the same pitch as the thread to be cut by the die. The guide is provided with two or more setscrews *f* and *g*, which when screwed down on the pipe rigidly clamp it and prevent the guide from turning; when the stock is revolved, they at the same time pull the die against the end of the pipe on which the thread is to be cut, and thus give it a start to cut the thread. The largest diameter pipe on which a thread can be cut with a stock is one whose outside diameter is equal to the diameter of the hole in the guide. To facilitate the threading of smaller pipes, a bushing *h* is used, the inside diameter of which is equal to that of the pipe, and the outside diameter is equal to the inside diameter of the guide, the bushing being held in place by the setscrews *f* and *g*. The bushings and dies are changed according to the diameter of the pipe to be threaded.

FIG. 46

Hand stocks, like the one shown in Fig. 44, are rarely used for pipes larger than 2 inches. Larger sizes of pipe are usually cut in threading machines, which generally work with a crank. The power on the handle of the crank is multiplied by gear-wheels and the speed of the dies is correspondingly decreased. In cutting threads on wrought pipes, machine oil should be freely poured on the pipes at the points where the dies are cutting. This cools the pipe and the teeth of the dies, and also lubricates the parts. It prevents the pipe from overheating and expanding, and the dies from losing their temper and becoming soft and easily dulled.

**37.** A *rachet stock* is a very handy tool for threading the end of a pipe where common dies cannot be swung, as, for example, in a trench, or in the corner of a cellar where a pipe

projects too far and must be cut off close to the wall and threaded in place. A ratchet stock is shown in Fig. 46. The lever handle *a* with the crosshead, when screwed down tightly, is used to hold the pipe steady between the jaws *b* while the die is turned by working the long handle *c* backwards and forwards. For one-man work this makes a desirable tool, as it eliminates the use of wrenches for holding the pipe while it is being threaded. After the thread is cut, the die is reversed by shifting a pawl *d* near the base of the long handle, which pawl operates the ratchet *e*.

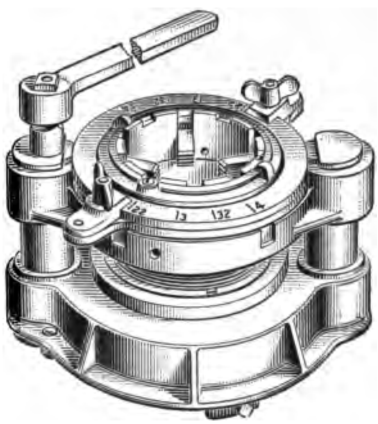


FIG. 47

**38.** In Fig. 47 is shown another type of ratchet stock for use on large pipe. A simpler form of ratchet stock, without the holding feature that was described in Fig. 46, is shown in Fig. 48. In this the dies are held in the part *a*, which is inserted in the opening *b* and can be turned by the action of the handle and the spring-operated pawl *c*. Such a stock can be used to thread pipe from $\frac{1}{8}$ to $\frac{3}{4}$ inch in diameter and can be carried in the kit.

A *pipe tap*, Fig. 49 (*a*), is used to cut a thread on the inside of a pipe or hole and is used in the same stock as the dies already described. Before using the tap, the inside of the pipe

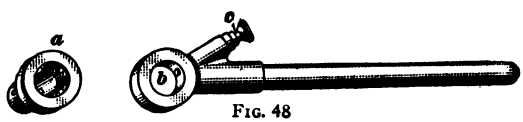
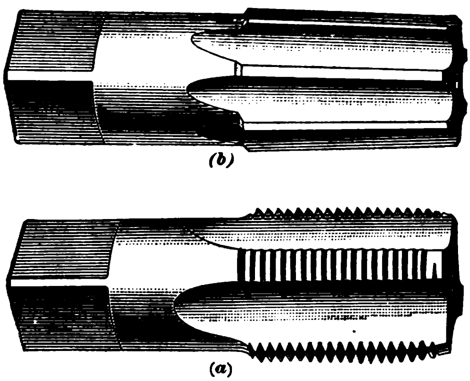



FIG. 48

or hole should be reamed smooth by use of a reamer such as shown in Fig. 49 (*b*). Taps and reamers are made in all iron-pipe sizes.

**39.** A *pipe vise*, used for holding a pipe rigid while it is being cut or threaded, is shown in Fig. 50. The toothed jaws *a*

are made of tempered steel and should be kept in good condition so that the pipe will not turn while being cut or threaded; as shown, the upper part *b* is pivoted to the base at *c*, and when closed on the pipe is held in place by the hook *d*.



(b)

(a)

Fig. 49

**40.** A *pipe bender*, used for making bends or offsets on iron pipe, is shown in Fig. 51. One end of the pipe is inserted through the ring, which holds it while the pipe is bent down over the curved part. By adjusting the height of the ring, any desired bend or offset can be made.

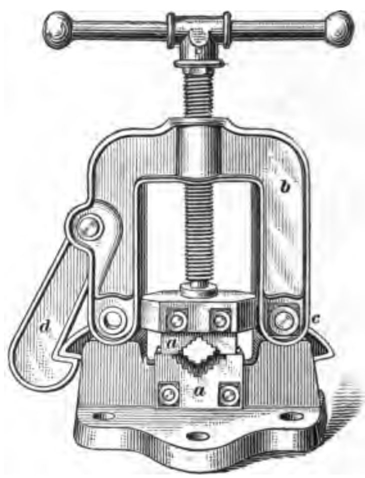



Fig. 50

**41.** *Seat dressers*, or *valve reseaters*, shown in Fig. 52, are used to turn down a valve or faucet seat when a washer will no longer stop its leaking. By use of a reseater, a new and uniform seat is obtained, different-size cutters being used according to the size of the valve to be reseated. A reseater commonly used on faucets is shown in Fig. 52 (*a*). It has a bonnet *a*, that may be screwed on the valve after the valve bonnet is removed. A stem *b* passes down through the center of the bonnet. A facing tool *c*, shaped as shown, is attached to the end of the stem inside the valve and a wheel or lever handle is attached to the other end. The tool *c* is pressed

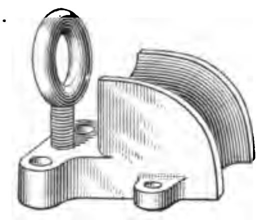
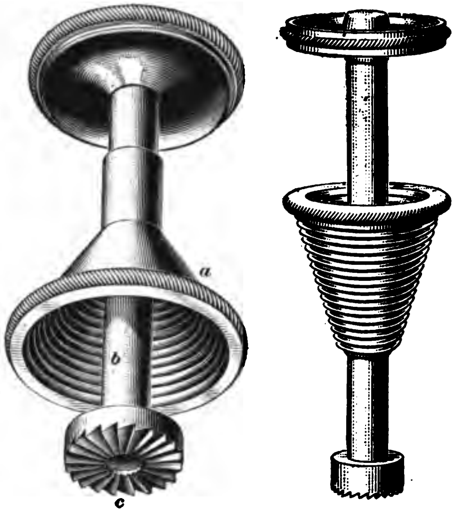


FIG. 51




(a) (b)

FIG. 52

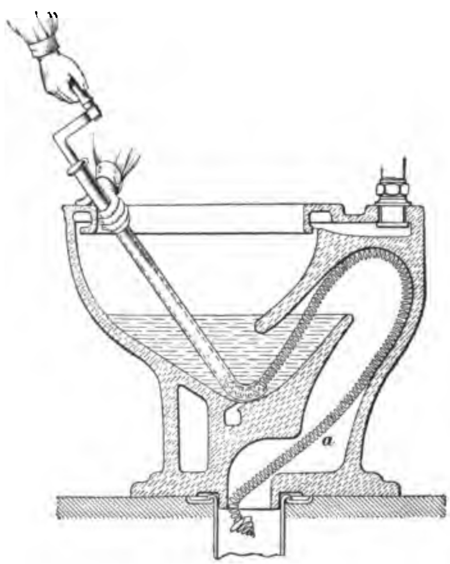



FIG. 53

down on the valve seat and revolved to the right, which causes it to cut down the valve seat true and smooth. The reseater shown in (*b*) is used for a valve where the top is connected to the valve by an inside thread. There are many sizes and makes of reseaters and every shop should have a set of them.

**42.** The *spiral auger,* shown in Fig. 53, is used for removing obstructions in the passages of closet bowls. By its use, any ordinary obstruction may be removed without disturbing the setting of the bowl, which is a great advantage. The auger consists of a long spiral spring *a* having an auger-like point and a handle, part of the spring being incased in a brass tube having a curve at its lower end so that it will reach around the trap in the closet. By turning the handle, the spring is worked through the passages and the auger point breaks up any obstruction so that it can be washed down by the water.

## PLUMBING MATERIALS

### EXPLANATION

**43.** The supplies necessary for the completion of a plumbing job consist of *plumbing materials* and *plumbing fixtures.*

The term **plumbing materials** includes soil pipe, lead pipe, wrought pipe, malleable and cast-iron fittings, sheet lead and other metals, oakum, solder, asphaltum, stop-cocks, faucets, straps, and everything used in the roughing in of a building; by **roughing in** is meant all of the plumbing work preliminary to the setting of the fixtures.

**Plumbing fixtures** consist of the finishing material, such as sinks, tubs, lavatories, drinking fountains, baths, urinals, water closets, boilers, ranges, etc., that is necessary to complete the plumbing.

The commonly used plumbing materials will be here described.

## SHEET METALS

### SHEET LEAD

**44. Sheet lead** is commercially pure metallic lead that has been rolled into sheets by passing blocks of the metal to and fro between heavy rolls until it has been rolled out to the desired thickness. This product is known as *milled sheet lead*. It is the only kind that can be obtained from plumbers' supply houses, that is, the firms or stores that supply material to plumbers, unless special orders are given to furnish *cast sheet lead*. This latter kind is made by first leveling a bed of fine molding sand, having the size and shape of the sheet desired, the sides and ends being formed into little embankments to prevent the molten lead running out of the bed, then pouring clean molten lead on the bed, and before it has set drawing a straight-edged board over it to give the lead a uniform thickness. Milled lead is much cheaper and stronger than cast lead, but it is not so soft nor so easily worked into different shapes. Cast sheet lead is used so seldom nowadays that manufacturers and dealers always assume that milled lead is wanted by their customers when no particular kind is specified.

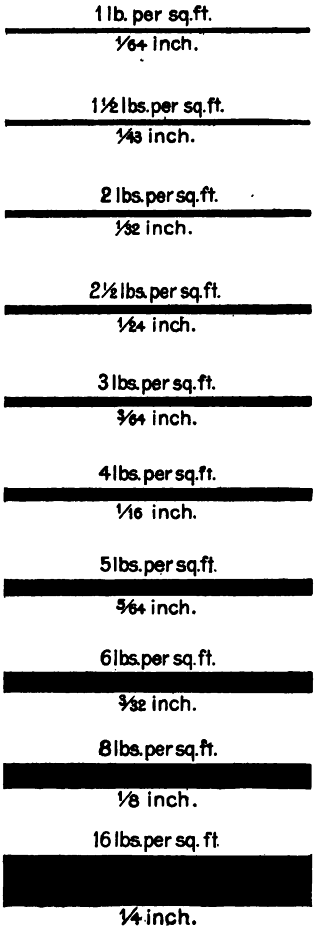



FIG. 54

**45.** Sheet lead is very malleable and can be worked into almost any shape. Its tenacity is low, and it is apt to tear if

stretched very much. It becomes hard and brittle if subjected to much bending or beating. Sheet lead is always specified and designated by its weight per square foot; thus, sheet lead weighing 6 pounds per square foot is called *6-pound sheet lead.*

It is manufactured in any thickness, weighing from 1 to 32 pounds, or more, a square foot. Fig. 54 shows the actual

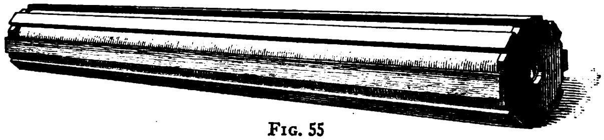


FIG. 55

thickness of sheet lead of the several weights. Sheets weighing less than $2\frac{1}{2}$ pounds a square foot are too light to be used in the plumbing trade. The kinds in common use vary from 4 to 8 pounds a square foot. The weights generally carried in stock by merchants are 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, 6, 7, and 8 pounds a square foot. Sheet lead is shipped to plumbers in rolls, similar to that shown in Fig. 55, varying in width from

**TABLE II**

**WEIGHTS AND USES OF LEAD**

For flashings use 4-pound sheet lead.
For hips and ridges use 6-pound sheet lead.
For roofs and gutters use 7-pound sheet lead.
1 cubic foot of lead weighs 711 pounds.
1 cubic inch of lead weighs $6\frac{7}{12}$ ounces.
Sheet lead. Pounds per square foot×.016=thickness in decimals of an inch.
All lead traps and bends should be of the same thickness and weight as their corresponding pipe branches.
Lead rolled 1 inch thick by 1 foot square weighs an average of 60 pounds.
Stowage capacity required per ton of lead is 4 cubic feet.

3 feet 6 inches to 9 feet, according to order. As sheet lead is easily cut and bruised by rough handling, it should be shipped in boxes. Special sheets for use in chemical manufactories, oil refineries, etc. can be had by special order. Sheet lead is used by plumbers in the United States of America chiefly

for lining water tanks, safes under the plumbing fixtures, roof flashings, etc. In Great Britain and other foreign countries it

### TABLE III

#### EFFECTS OF ACIDS ON LEAD

**Sulphuric Acid.**—The purer the lead the less it will be attacked by pure or *nitrous sulphuric acid* up to 200° C., the highest temperature employed under normal conditions in concentrating pans; above 200° C., the action becomes stronger and at 260° C. the lead is dissolved. *Concentrated nitrous sulphuric acid* acts at all temperatures more powerfully than pure sulphuric acid, and the effect is greater in the presence of air. *Dilute nitrous sulphuric acid* of a specific gravity of 1.72–1.76 is not so powerful as the pure acid, although if the dilution be continued beyond this point the power increases again instead of diminishing. Boiling sulphuric acid of sp. gr. 1.84 acts severely on lead, and fuming acid still more so.

**Organic Acids.**—*Acetic, tartaric,* and *citric acids* attack lead in contact with air.

**Nitric acid** dissolves lead, forming *nitrate of lead.* This acid acts very energetically when dilute but more slowly when concentrated owing to the nitrate of lead being insoluble in strong nitric acid.

**Hydrochloric acid** has practically no action on lead. Boiling concentrated hydrochloric and sulphuric acid of 66° B. dissolve it slowly.

**Aqua regia** converts lead into a chloride.

**Arsenic** or **arsenious acid** unites with lead, yielding arsenite or arsenide of lead.

**Peat acids** in water rapidly dissolve lead.

**Chlorate of potash** dried upon lead-covered tables will be found to contain traces of lead.

Gases of a properly worked sulphuric-acid plant have a very mild action upon the sheet lead of which the chambers are built, and when any severe action takes place some abnormal condition is sure to have been the cause.

**Chlorine** does not attack lead to any serious extent; but when chlorine is accompanied by traces of hydrochloric gas the damage is often extensive.

**Lime wash** upon lead after having dried helps *chlorine* to form the *purple oxide of lead.* This shortens the life of the lead, and such wash should not be used on the outside of bleaching-powder chambers.

is used extensively by plumbers for covering flat roofs, and for ridges, valleys, gutters, and flashings of pitched roofs.

Table II shows the weights of lead in various forms, and the weights to be used for different purposes. Table III shows the effects of acids on lead. This effect is important in many classes of construction where lead pipe and sheet lead are used.

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### SHEET COPPER

**46. Sheet copper** is copper rolled into sheets by heavy steel rolls. The forms in use are: Hot-rolled, cold-rolled and annealed, cold-rolled, and cold-rolled and polished. Any of these kinds may also be obtained tinned on one or both sides. Sheet copper is designated by its weight in ounces per square foot. The sheets in common use range from 10 to 20 ounces a square foot; the largest sheets of 10-ounce copper usually kept in stock are 48 in.×96 in. The heavier sheets are made 60 in.× 96 in. Rolled copper has a specific gravity of 8.93. One cubic foot weighs $558\frac{125}{1000}$ pounds, while 1 square foot, 1 inch thick, weighs $46\frac{51}{100}$ pounds. The weights and dimensions of the standard sizes of sheets are given in Table IV, which has been adopted as the official table by the Association of Copper Manufacturers of the United States.

**47.** Hot-rolled, sometimes called soft-rolled, copper coated with tin on one side is generally used by plumbers for lining tanks, safes, etc., and for such purposes it should be not less than 16-ounce. Nearly all water-closet flushing tanks are lined with sheet copper. Commonly, sheet copper is numbered, according to its thickness, by the Stubs's gauge; but sheet brass is numbered according to Brown & Sharpe's gauge. When the name of the gauge is not given with an order for sheet brass or copper, orders are usually filled to correspond with the gauges just named. When ordering sheet copper, where gauge number or weight is unknown, the difficulty may be overcome by enclosing a sample piece with the order. When ordering sheet copper, the *temper* desired should always be stated, that is, whether hard, semiannealed, or soft; also the surface finish desired, that is, whether plain, tinned, cold-rolled and tinned and polished, cold-rolled and tinned and not

# TABLE IV

## SIZES AND WEIGHTS OF SHEET COPPER

| Weight per Square Foot Ounces | Weight of Sheet 14 In. × 48 In. Pounds | Weight of Sheet 24 In. × 48 In. Pounds | Weight of Sheet 30 In. × 60 In. Pounds | Weight of Sheet 36 In. × 72 In. Pounds | Weight of Sheet 48 In. × 72 In. Pounds | Thickness Inch | Stubs's Gauge Number |
|---|---|---|---|---|---|---|---|
| 4 | 1.16 | 2.0 | 3.12 | 4.50 | 6 | .00537 | 35 |
| 6 | 1.75 | 3.0 | 4.68 | 6.75 | 9 | .00806 | 33 |
| 8 | 2.33 | 4.0 | 6.25 | 9.00 | 12 | .01070 | 31 |
| 10 | 2.91 | 5.0 | 7.81 | 11.25 | 15 | .01340 | 29 |
| 12 | 3.50 | 6.0 | 9.37 | 13.50 | 18 | .01610 | 27 |
| 14 | 4.08 | 7.0 | 10.93 | 15.75 | 21 | .01880 | 26 |
| 16 | 4.66 | 8.0 | 12.50 | 18.00 | 24 | .02150 | 24 |
| 18 | 5.25 | 9.0 | 14.06 | 20.25 | 27 | .02420 | 23 |
| 20 | 5.83 | 10.0 | 15.62 | 22.50 | 30 | .02690 | 22 |
| 24 | 7.00 | 12.0 | 18.75 | 27.00 | 36 | .03220 | 21 |
| 32 | 9.33 | 16.0 | 25.00 | 36.00 | 48 | .04300 | 19 |
| 40 | 11.66 | 20.0 | 31.25 | 45.00 | 60 | .05380 | 18 |
| 48 | 14.00 | 24.0 | 37.50 | 54.00 | 72 | .06450 | 16 |
| 56 | 16.33 | 28.0 | 43.75 | 63.00 | 84 | .07540 | 15 |
| 64 | 18.66 | 32.0 | 50.00 | 72.00 | 96 | .08600 | 14 |
| 70 | | 35.0 | 55.00 | 79.00 | 105 | .09500 | 13 |
| 81 | | 40.5 | 63.00 | 91.00 | 122 | .10900 | 12 |
| 89 | | 44.5 | 70.00 | 100.00 | 134 | .12000 | 11 |
| 100 | | 50.0 | 78.00 | 112.00 | 150 | .13400 | 10 |
| 110 | | 55.0 | 86.00 | 124.00 | 165 | .14800 | 9 |
| 123 | | 61.0 | 96.00 | 138.00 | 184 | .16500 | 8 |
| 134 | | 67.0 | 105.00 | 151.00 | 201 | .18000 | 7 |
| 151 | | 75.5 | 118.00 | 170.00 | 227 | .20300 | 6 |
| 164 | | 82.0 | 128.00 | 184.00 | 246 | .22000 | 5 |
| 177 | | 88.5 | 138.00 | 199.00 | 266 | .23800 | 4 |
| 193 | | 96.0 | 151.00 | 217.00 | 289 | .25900 | 3 |
| 211 | | 105.5 | 165.00 | 238.00 | 317 | .28400 | 2 |
| 223 | | 111.5 | 174.00 | 251.00 | 335 | .30000 | 1 |
| 253 | | 126.5 | 198.00 | 285.00 | 380 | .34000 | 0 |

TABLE V

STOCK SIZES OF SHEET COPPER

| Kind of Copper | Size of Sheet Inches | Weight of 1 Square Foot Ounces |
|---|---|---|
| Plain | 24×48 | 10 to 40 |
| Plain | 30×60 | 9 to 154 |
| Plain | 48×72 | 20 to 100 |
| Tinned | 10×48 | 14 |
| Tinned | 12×48 | 14 |
| Tinned | 14×48 | 12 to 20 |
| Tinned | 24×48 | 10 to 18 |
| Tinned | 30×60 | 10 to 20 |
| Tinned | 36×72 | 16 |
| Tinned | 48×72 | 16 |
| Tinned | 48×96 | 16 |
| Cold-rolled and tinned, polished | 10×48 | 14 |
| Cold-rolled and tinned, polished | 12×48 | 14 |
| Cold-rolled and tinned, polished | 12×60 | 14 |
| Cold-rolled and tinned, polished | 14×48 | 14 and 16 |
| Cold-rolled and tinned, polished | 14×52 | 14 |
| Cold-rolled and tinned, polished | 14×56 | 14 and 16 |
| Cold-rolled and tinned, polished | 14×60 | 14 and 16 |
| Cold-rolled and tinned, polished | 24×48 | 14 and 16 |
| Cold-rolled and tinned, polished | 30×60 | 16, 18, and 20 |
| Cold-rolled and tinned, not polished | 24×48 | 14 and 16 |
| Cold-rolled and tinned, not polished | 30×60 | 14, 16, and 20 |
| Cornice copper | 20×96 | 16 and 18 |
| Cornice copper | 24×48 | 14 and 16 |
| Cornice copper | 24×96 | 14 and 16 |
| Cornice copper | 30×60 | 14, 16, and 18 |
| Cornice copper | 30×72 | 14, 16, and 18 |
| Cornice copper | 30×96 | 14, 16, 18, and 20 |
| Cornice copper | 36×72 | 16 and 18 |
| Cornice copper | 36×96 | 16, 18, and 20 |
| Planished copper, tinned on one side | 12×48 | 14 |
| Planished copper, tinned on one side | 14×52 | 14 |
| Planished copper, tinned on one side | 14×56 | 14 |
| Planished copper, tinned on one side | 14×60 | 14 |
| Planished copper, tinned on one side | 14×48 | 12 to 20 |
| Planished copper, tinned on one side | 24×48 | 14 and 16 |
| Planished copper, tinned on one side | 30×60 | 16 and 20 |

polished, or planished copper tinned on one side. On account of its durability, copper is taking the place of tin and galvanized iron for valleys, conductors, gutters, etc. The size of the sheets that are best suited to the purpose should be specified. Cold-rolled copper is smooth and clean, being carefully buffed to a high polish, which, however, will tarnish, because the polished surface is not protected from the action of the weather. *Planished copper* is highly polished and coated with an elastic enamel, which prevents its tarnishing.

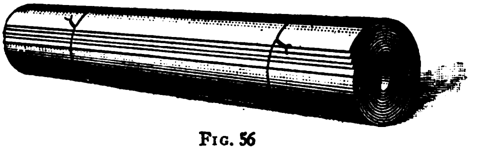

FIG. 56

Planished copper is used to a great extent for covering drain boards. It can be corrugated or crimped, but when ordering for such purposes care must be taken to specify the proper width, for if a space 14½ inches wide on a sheet of copper 24 inches wide is corrugated, the width of the sheet will then be about 21½ inches. All unprotected copper will tarnish rapidly. Copper becomes hard if it is hammered. Sheet copper is shipped in rolls, as shown in Fig. 56, and may or may not be boxed. Table V shows the sizes and weights of copper sheets in most common use.

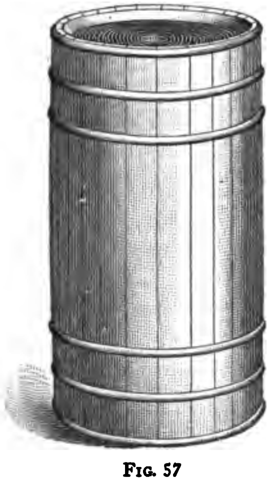

FIG. 57

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### SHEET ZINC

**48. Sheet zinc** is designated by its weight in ounces per square foot. It is furnished in casks or rolls as ordered. A cask of zinc is shown in Fig. 57; this cask weighs about 600 pounds. The weights and thicknesses of the sheets are given in Table VI. Zinc is a bluish-white metal and is highly crystalline. It is hard and brittle both at the ordinary temperature and at 400° F. But at intermediate temperatures, between

# TABLE VI

## WEIGHTS, GAUGE, AND SIZES OF SHEET ZINC

| Zinc gauge, Nos. | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight per square foot in pounds | | .30 | 37 | .45 | .52 | .60 | .67 | .75 | .90 | 1.05 | 1.20 | 1.35 | 1.50 | 1.68 | 1.87 | 2.06 | 2.25 | 2.62 | 3.00 | 3.37 |
| Approximate thickness in inches | | .008 | .010 | .012 | .014 | .016 | .018 | .020 | .024 | .028 | .032 | .036 | .040 | .045 | .050 | .055 | .060 | .070 | .080 | .090 |
| Size of Sheet | Sq. Ft. per Sheet | Approximate Weight Per Sheet in Pounds | | | | | | | | | | | | | | | | | | |
| 24×84 | 14.0 | 4.2 | 5.2 | 6.3 | 7.3 | 8.4 | 9.4 | 10.5 | 12.6 | 14.7 | 16.8 | 18.9 | 21.0 | 23.5 | 26.2 | 28.9 | 31.5 | 36.7 | 42.0 | 47.2 |
| 26×84 | 15.2 | 4.6 | 5.6 | 6.9 | 7.9 | 9.1 | 10.2 | 11.4 | 13.7 | 16.0 | 18.3 | 20.5 | 22.8 | 25.6 | 28.4 | 31.3 | 34.2 | 39.9 | 45.6 | 51.2 |
| 28×84 | 16.3 | 4.9 | 6.0 | 7.4 | 8.5 | 9.8 | 10.9 | 12.2 | 14.7 | 17.1 | 19.6 | 22.0 | 24.5 | 27.4 | 30.5 | 33.6 | 36.7 | 42.7 | 48.9 | 54.9 |
| 30×84 | 17.5 | 5.3 | 6.5 | 7.9 | 9.1 | 10.5 | 11.8 | 13.2 | 15.8 | 18.4 | 21.0 | 23.6 | 26.2 | 29.4 | 32.8 | 36.1 | 39.4 | 45.8 | 52.5 | 59.0 |
| 32×84 | 18.7 | 5.6 | 6.9 | 8.4 | 9.7 | 11.2 | 12.6 | 14.1 | 16.9 | 19.7 | 22.5 | 25.3 | 32.8 | 31.4 | 35.0 | 38.5 | 42.0 | 49.0 | 56.1 | 63.0 |
| 34×84 | 19.9 | 6.0 | 7.4 | 9.0 | 10.4 | 12.0 | 13.4 | 15.0 | 18.0 | 20.9 | 23.9 | 26.9 | 29.9 | 33.4 | 37.2 | 41.0 | 44.8 | 52.2 | 59.7 | 67.0 |
| 36×84 | 21.0 | 6.3 | 7.8 | 9.5 | 10.9 | 12.6 | 14.1 | 15.8 | 18.9 | 22.0 | 25.2 | 28.4 | 31.5 | 35.3 | 39.3 | 43.3 | 47.2 | 55.0 | 63.0 | 70.8 |
| 36×96 | 24.0 | 7.2 | 8.9 | 10.8 | 12.5 | 14.4 | 16.1 | 18.0 | 21.6 | 25.2 | 28.8 | 32.4 | 36.0 | 40.3 | 44.9 | 49.5 | 54.0 | 62.8 | 72.0 | 80.9 |
| 36×108 | 27.0 | 8.1 | 10.0 | 12.2 | 14.1 | 16.2 | 18.1 | 20.3 | 24.3 | 28.4 | 32.4 | 36.5 | 40.5 | 45.4 | 50.5 | 55.6 | 60.7 | 70.7 | 81.0 | 91.0 |
| 40×84 | 23.4 | 7.0 | 8.7 | 10.6 | 12.2 | 14.1 | 15.7 | 17.6 | 21.0 | 24.6 | 28.1 | 31.6 | 35.1 | 39.3 | 43.8 | 48.2 | 52.6 | 61.3 | 70.2 | 78.8 |
| 40×96 | 26.8 | 8.0 | 9.9 | 12.1 | 14.0 | 16.1 | 18.0 | 20.1 | 24.1 | 28.1 | 32.2 | 36.2 | 40.2 | 45.0 | 50.1 | 55.2 | 60.3 | 70.2 | 80.4 | 90.3 |
| 44×84 | 25.7 | 7.7 | 9.5 | 11.6 | 13.4 | 15.4 | 17.2 | 19.3 | 23.1 | 27.0 | 30.8 | 34.7 | 38.6 | 43.2 | 48.1 | 53.0 | 57.8 | 67.4 | 77.1 | 86.6 |
| 46×90 | 28.7 | 8.6 | 10.6 | 12.9 | 14.9 | 17.2 | 19.2 | 21.5 | 25.8 | 30.1 | 34.4 | 38.7 | 43.0 | 48.2 | 53.7 | 59.1 | 64.6 | 75.2 | 86.1 | 96.7 |
| 48×84 | 28.0 | 8.4 | 10.4 | 12.6 | 14.6 | 16.8 | 18.8 | 21.0 | 25.2 | 29.1 | 33.6 | 37.8 | 42.0 | 47.0 | 52.4 | 57.7 | 63.0 | 73.4 | 84.0 | 94.1 |
| 48×96 | 32.0 | 9.6 | 11.9 | 14.4 | 16.7 | 19.2 | 21.5 | 24.0 | 28.8 | 33.6 | 38.4 | 43.2 | 48.0 | 53.8 | 59.9 | 65.9 | 72.0 | 83.9 | 96.0 | 107.8 |
| 50×108 | 37.5 | 11.3 | 13.9 | 16.9 | 19.5 | 22.5 | 25.1 | 28.2 | 33.8 | 39.3 | 45.0 | 50.7 | 56.3 | 63.0 | 70.1 | 77.3 | 84.4 | 98.3 | 112.5 | 126.4 |
| 52×84 | 30.4 | 9.1 | 11.3 | 13.7 | 15.8 | 18.3 | 20.4 | 22.8 | 27.4 | 31.9 | 36.5 | 41.0 | 45.6 | 51.0 | 56.9 | 62.6 | 68.4 | 79.6 | 91.2 | 102.5 |

212° F. and 302° F., it is malleable and ductile, and can then be rolled into thin sheets.

NOTE.—The initial letter F. is an abbreviation of the word Fahrenheit. Thus, 400° F. means a temperature of 400° on the Fahrenheit thermometer, the one ordinarily used in the United States and Great Britain. Unless otherwise stated, all degrees of temperature will be according to the Fahrenheit thermometer, whether so indicated or not.

Zinc is seldom used by plumbers in the United States, except for waterproofing such chambers as ice chests, or for lining corn bins in stables, or small water tanks. The weights most commonly used are 12-, 14-, and 16-ounce, the latter being used chiefly for tank linings.

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#### SHEET BLOCK TIN

**49.** Tin in sheet form, like sheet lead, is made by the rolling process from solid blocks of the pure metal. It can be had in sheets of the same length and breadth as sheet lead, and, like lead, is known by its weight in pounds per square foot. Owing to its lower specific gravity, tin sheets are thicker than lead sheets of the same weight per square foot. Fig. 58 shows the thickness of the common grades usually kept in stock by manufacturers. The sizes mostly used by plumbers are 1½ to 3 pounds, inclusive, the latter being used chiefly for tanks and the former for flashing around pantry sinks, etc. To distinguish this sheet metal from tin-coated iron sheets, it is called **sheet block tin.**

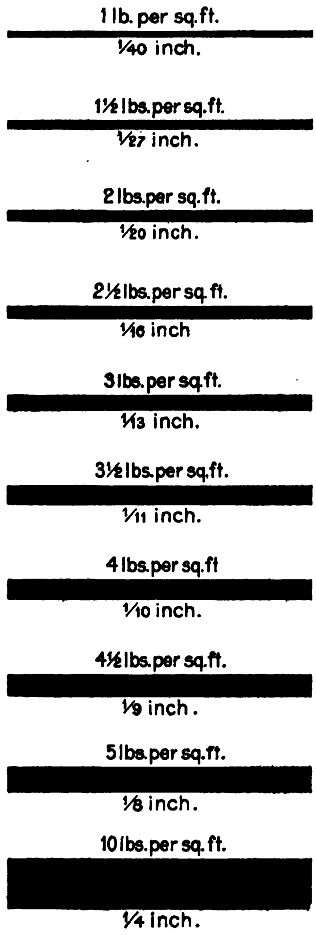


FIG. 58

# TABLE VII

## UNITED STATES STANDARD GAUGE FOR SHEET AND PLATE IRON AND STEEL

| Number of Gauge | Approximate Thickness Fractions of 1 Inch | Approximate Thickness Decimal Parts of 1 Inch | Weight of Square Foot of Iron Pounds Avoirdupois | Weight of Square Foot of Steel Pounds Avoirdupois |
|---|---|---|---|---|
| 0000000 | $\frac{1}{2}$ | .500000000 | 20.000000 | 20.4000000 |
| 000000 | $\frac{15}{32}$ | .468750000 | 18.750000 | 19.1250000 |
| 00000 | $\frac{7}{16}$ | .437500000 | 17.500000 | 17.8500000 |
| 0000 | $\frac{13}{32}$ | .406250000 | 16.250000 | 16.5750000 |
| 000 | $\frac{3}{8}$ | .375000000 | 15.000000 | 15.3000000 |
| 00 | $\frac{11}{32}$ | .343750000 | 13.750000 | 14.0250000 |
| 0 | $\frac{5}{16}$ | .312500000 | 12.500000 | 12.7500000 |
| 1 | $\frac{9}{32}$ | .281250000 | 11.250000 | 11.4750000 |
| 2 | $\frac{17}{64}$ | .265625000 | 10.625000 | 10.8375000 |
| 3 | $\frac{1}{4}$ | .250000000 | 10.000000 | 10.2000000 |
| 4 | $\frac{15}{64}$ | .234375000 | 9.375000 | 9.5625000 |
| 5 | $\frac{7}{32}$ | .218750000 | 8.750000 | 8.9250000 |
| 6 | $\frac{13}{64}$ | .203125000 | 8.125000 | 8.2875000 |
| 7 | $\frac{3}{16}$ | .187500000 | 7.500000 | 7.6500000 |
| 8 | $\frac{11}{64}$ | .171875000 | 6.875000 | 7.0125000 |
| 9 | $\frac{5}{32}$ | .156250000 | 6.250000 | 6.3750000 |
| 10 | $\frac{9}{64}$ | .140625000 | 5.625000 | 5.7375000 |
| 11 | $\frac{1}{8}$ | .125000000 | 5.000000 | 5.1000000 |
| 12 | $\frac{7}{64}$ | .109375000 | 4.375000 | 4.4625000 |
| 13 | $\frac{3}{32}$ | .093750000 | 3.750000 | 3.8250000 |
| 14 | $\frac{5}{64}$ | .078125000 | 3.125000 | 3.1875000 |
| 15 | $\frac{9}{128}$ | .070312500 | 2.812500 | 2.8687500 |
| 16 | $\frac{1}{16}$ | .062500000 | 2.500000 | 2.5500000 |
| 17 | $\frac{9}{160}$ | .056250000 | 2.250000 | 2.2950000 |
| 18 | $\frac{1}{20}$ | .050000000 | 2.000000 | 2.0400000 |
| 19 | $\frac{7}{160}$ | .043750000 | 1.750000 | 1.7850000 |
| 20 | $\frac{3}{80}$ | .037500000 | 1.500000 | 1.5300000 |
| 21 | $\frac{11}{320}$ | .034375000 | 1.375000 | 1.4025000 |
| 22 | $\frac{1}{32}$ | .031250000 | 1.250000 | 1.2750000 |
| 23 | $\frac{9}{320}$ | .028125000 | 1.125000 | 1.1475000 |
| 24 | $\frac{1}{40}$ | .025000000 | 1.000000 | 1.0200000 |
| 25 | $\frac{7}{320}$ | .021875000 | .875000 | .8925000 |
| 26 | $\frac{3}{160}$ | .018750000 | .750000 | .7650000 |
| 27 | $\frac{11}{640}$ | .017187500 | .687500 | .7012500 |
| 28 | $\frac{1}{64}$ | .015625000 | .625000 | .6375000 |
| 29 | $\frac{9}{640}$ | .014062500 | .562500 | .5737500 |
| 30 | $\frac{1}{80}$ | .012500000 | .500000 | .5100000 |
| 31 | $\frac{7}{640}$ | .010937500 | .437500 | .4462500 |
| 32 | $\frac{13}{1280}$ | .010156250 | .406250 | .4143750 |
| 33 | $\frac{3}{320}$ | .009375000 | .375000 | .3825000 |
| 34 | $\frac{11}{1280}$ | .008593750 | .343750 | .3506250 |
| 35 | $\frac{5}{640}$ | .007812500 | .312500 | .3187500 |
| 36 | $\frac{9}{1280}$ | .007031250 | .281250 | .2868750 |
| 37 | $\frac{17}{2560}$ | .006640625 | .265625 | .2709375 |
| 38 | $\frac{1}{160}$ | .006250000 | .250000 | .2550000 |

### SHEET IRON AND STEEL

**50. Black, Galvanized, and Russia Iron.**—Iron and steel in the form of sheets, called *sheet iron* and *sheet steel*, respectively, can be obtained cold rolled and hard, or annealed and soft. Either kind can be had in the natural state, when it is called **black,** or coated with zinc, when it is called **galvanized.** Sheets range in size from 24 in.×72 in. for the thin sheets, to 30 in.×84 in. or larger for the heavier ones. Sheet iron is designated by its thickness as measured by a wire gauge. Many varieties of gauges are used for this purpose, which differ greatly in their measurements.

The gauge in most common use in the United States of America is given in Table VII, which has been adopted as a standard by the American Railway Master Mechanics' Association and also by the Association of American Steel Manufacturers.

**51.** As there are different gauges in use by the different manufacturers, and as the thickness of a sheet stamped with the same gauge number varies according to the kind of gauge used by the manufacturer of that sheet, the weight per square foot, or the thickness in thousandths of an inch should be specified when ordering sheet metal.

Sheet iron is shipped in flat bundles put up as shown in Fig. 59, firmly clamped together with strap-iron bands. Each sheet should be stamped with the maker's trade-mark and the gauge number.

**52. Russia iron** is a class of sheet iron having its surface especially prepared to resist corrosion by a covering of flexible, transparent enamel. Genuine Russia iron is made in Russia, but American-made Russia iron which is fully equal to the imported product can now be obtained. Russia iron, on account of its durability and smooth surface, is used extensively in manufacture of gas-stove casings, top ovens, heating and smoke pipes, etc.

**53. Sheet Tin.**—The article of commerce known as *sheet tin*, and also as *roofing tin*, is not tin in the true sense; it is

a thin steel or wrought-iron sheet coated on both sides with block tin. The strength is given by the iron or steel body and the durability is imparted by the tin coating, which especially protects the sheets against the weather. Sheet tin is generally employed for roofing purposes. City plumbers seldom use it, for tinsmiths do all tin work there; but in country towns and villages the plumbers should have a fair knowledge of tin work, as they are called upon to do that sort of work. When plates are coated with tin alone, they are known as *tin plates;* when coated with a mixture of lead and tin, they are known as *terne plates.*

**54.** The original method of manufacture was to dip the plates into the melted covering material, the sheets being allowed to take on all the coating possible. Many of the

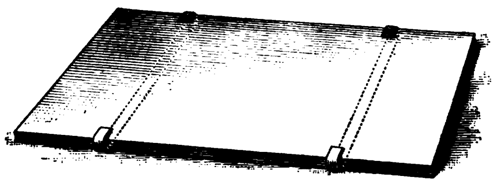

FIG. 59

best grades of roofing tin are still made by this process. Another method is known as the *patent-roller process,* by which the plates are put into a bath of molten covering material and then passed between iron rolls. The pressure on the rolls leaves on the plates a thickness of coating that is determined by the distance the rolls are apart and the thickness of the sheet. The rolls can be adjusted to squeeze off nearly all the coating, or to leave it on, just as the manufacturer sees fit, and just as the trade will accept or reject the material.

There are different brands of roofing plates in the market at present. Some are called *double-coated,* some *redipped,* others *double-dipped,* etc. These terms are somewhat misleading, for they seem to imply that the sheets have been dipped twice in tin.

To test tin plates, a knife may be run over the surface and the covering peeled off, as shown in Fig. 60, in order to dis-

cover its thickness. It is very important that the thickness of the coating should be tested before the tin is allowed to go on a roof.

**55.** To avoid trouble, the best manufacturers have an assorting department, where the defective sheets are picked out and separated from the good ones. In the manufacture of roofing plates, imperfect sheets, such as sheets with blisters, broken corners, cracks, and other flaws, occur. All these sheets are called *wasters* and are packed separately, the boxes containing IC sheets being marked "ICW," and those con-

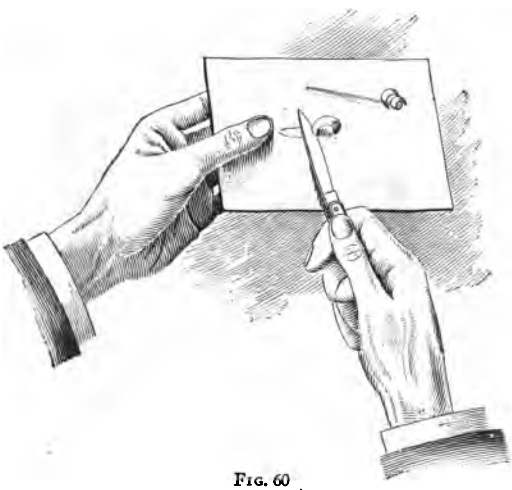

FIG. 60

taining IX sheets, "IXW." Wasters are always sold at prices considerably lower than the *primes*, or perfect sheets, of the same brand. Tin and terne plates for roofing and other purposes are shipped in boxes, as shown in Fig. 61.

**56.** There are two regular sizes of roofing plates, namely, 20 in.×28 in., and 14 in.×20 in. The larger size is generally used for making heater pipe or for valleys. The 14″×20″ size is best adapted for roofing, as the larger size bulges or buckles and cracks the seams, thereby causing leaks in the roof. A third size, namely, 10 in.×20 in., is also supplied, and is used generally for gutters and leader pipes.

Two thicknesses of roofing plates are commonly recognized: the IC, which is No. 29 gauge and weighs 9 ounces to the square foot; and the IX, or No. 27 gauge, which weighs 10 ounces to the square foot. Sometimes a still heavier plate is called for; therefore, it is kept in stock by the best manufacturers; this plate is known as IXX, or No. 26 gauge, which is used for specially heavy work.

The standard net weight of a box of IC 14″×20″ roofing tin formerly was 112 pounds, or 1 pound per sheet, making

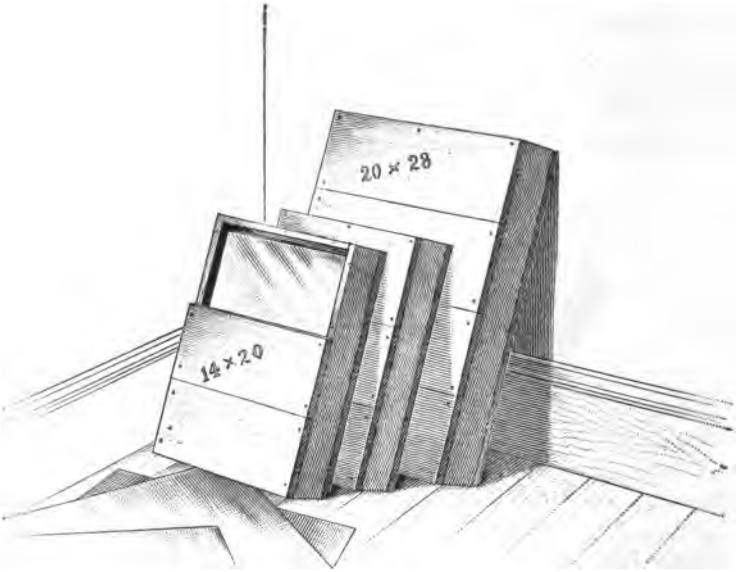


FIG. 61

112 sheets to the box, but now it is reduced to 108 pounds. The old standard for IX plates was 140 pounds, but very few brands now weigh more than 135 pounds. The most reliable manufacturers guarantee the weights for the different boxes, and if the boxes do not come up to the guaranteed weight, they may be shipped back. The best sheets on the market today are stamped with the mark of the brand, and with the thickness designation IC or IX.

# PLUMBING TOOLS AND MATERIALS
(PART 2)

## PLUMBING MATERIALS—(Continued)

### SOLDER

**1. Solder** is an alloy of two or more metals that, when melted, will adhere strongly to the cleaned surfaces of other metals that are less fusible. Solders are classified as *hard* or *soft*, according to their relative fusibility. Any desired fusing point may be obtained by varying the proportions and kinds of ingredients. Table I shows the composition and fusing points of the various solders in common use.

Hard solders are only used by plumbers in exceptional cases where brass, copper, or iron tubes or other work needs to be brazed in order to make it stronger. Soft solders are known to plumbers as *strap solder,* which is used for soldering with the copper bit; and *wiping solder,* which is used for making wiped joints. Fig. 1 shows a bar of strap solder of the brand known as *half and half*. Each bar weighs about 1 pound.

Fig. 2 shows a bar, or ingot, of wiping solder. Each bar weighs about 5 pounds. Solder should always be purchased from reliable supply houses, for to use low-grade solders is false economy.

**2. Making Soft Solder.**—Ordinary soft solder contains about 40 per cent. tin and 60 per cent. lead; finer grades contain a greater proportion of tin, half and half containing equal

quantities of each. To make good solder, pure materials are essential; the lead and tin of commerce vary in purity. After determining the proper proportions of lead and tin required

### TABLE I

**SOLDERS**

| Variety | Hard | | | Soft | | | Fusing Point Degrees F. |
|---|---|---|---|---|---|---|---|
| | Zinc | Copper | Silver | Tin | Lead | Bismuth | |
| Spelter, hardest | 1 | 2 | | | | | 700 |
| Spelter, hard | 2 | 3 | | | | | |
| Spelter, soft | 1 | 1 | | | | | 550 |
| Spelter, fine | 2 | 2 | $\frac{1}{4}$ | | | | |
| Silver, hard | | 1 | 4 | | | | |
| Silver, medium | | 1 | 3 | | | | |
| Silver, soft | | 1 | 2 | | | | |
| Plumbers', coarse | | | | 1 | 3 | | 480 |
| Plumbers', ordinary | | | | 1 | 2 | | 441 |
| Plumbers', fine | | | | 2 | 3 | | 400 |
| Tinners' | | | | 1 | 1 | | 370 |
| For tin pipe | | | | 3 | 2 | | 330 |
| For tin pipe | | | | 4 | 4 | 1 | |

to make the desired kind of solder, the lead should be melted, care being taken to avoid overheating the metal. The melted metal should be stirred thoroughly and the dross that floats on the surface removed. The tin should then be added, and as soon as it has melted, the metals should be stirred until thoroughly mixed; meanwhile a small quantity of black rosin should be added. When the metal becomes hot enough to ignite a piece of newspaper, it should be skimmed and poured into clean, dry molds.


Fig. 1

The two metals will separate if the melted solder is allowed to stand without stirring, because of the difference in specific gravity of the lead and tin, their weights being in the proportion of 11 to 7; therefore, thorough stirring is indispensable.

Soft solder is quickly spoiled by overheating; therefore, it should not be allowed to get red hot. Both lead and tin oxidize rapidly at a low, red heat, but the tin oxidizes faster than the lead. If the solder does get red hot, a thick, yellow crust will form on the surface of the molten metal, which will exclude the air and retard oxidization. If this crust is left undisturbed until the metal cools to the proper working temperature, which is not over 600°, and is then removed, the solder may be made as good as before by the addition of a little tin. The molten metal should not be stirred while any oxide remains on its surface.

FIG. 2

**3. Purifying Soft Solder.** Soft solder becomes impure and useless by the gradual accumulation of oxides, or iron and brass filings, and also by contamination with zinc. Where solder is being used for wiping joints on service pipes, it must not be used for tinning solder nipples, etc. They should be tinned with a copper bit. Many a batch of good solder has been spoiled by tinning solder nipples, brass ferrules, etc., in the pot. A common method of purifying impure soft solder is to heat the metal to about 800°, which is a very dull red heat, just visible in the dark but invisible in daylight. Then throw a quantity of sulphur upon the metal as soon as it is melted. The metal is then well stirred in order to mix it thoroughly with the sulphur, which combines with the zinc and brings it to the surface as dross. The oxides will also come to the surface; sometimes they will cling to the sides of the pot. The metal is then thoroughly skimmed—the crust being taken off whole, if possible—and allowed to cool to low working heat, about 480°; a little tallow is then stirred in to remove the last of the sulphur, and the metal will appear very clean. It will

probably require the addition of a little tin to restore it to its former quality.

Sometimes a batch of soft solder will work well for about a dozen heats and then become unworkable. This condition is usually due to impurities in the tin, such as antimony or bismuth. If the impurities cannot be removed, the solder should be put aside until such a time as it can be refined, and a new batch melted.

As a proof that the tin will separate from the lead when the solder is in a plastic state, dig a hole in the nearly-set solder in the pot, and the tin will filter down and settle in a little pool at the bottom of the hole, leaving a chalky-looking and porous metal above.

**4. Testing the Quality of Soft Solder.**—To test the quality of soft solder, raise the solder to a temperature of

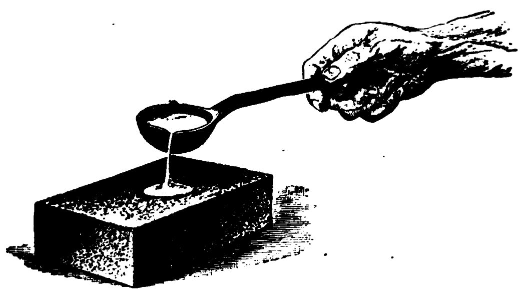

FIG. 3

about 600°, at which heat paper will scorch but not ignite, then pour, as shown in Fig. 3, the solder upon a stone that is perfectly dry, clean, and level, until it forms a cake as large as a dollar, and about $\frac{1}{8}$ inch thick. Good solder will show a number of clear spots, from four to six to the inch, upon the top surface of the cake. If the cake turns white and chalky, the solder is probably too coarse; that is, the percentage of lead is too great. If it cools with a bright top surface, with perhaps a little gray or chalky center, the percentage of tin is too great.

The best way of testing the quality of solder is to prepare a lead pipe and make a wiped joint. If the solder is good, it

will cling to the pipe and remain plastic until too cool to work. If the proportion of tin is too great, the solder will set or harden too quickly, the metal will appear bright, and beads of tin will probably drop from the under side of the joint. If the proportion of lead is too great, a long time will be required

**TABLE II**

**FLUXES**

| Flux | Metals to be Joined |
|---|---|
| Rosin | Lead, tin, copper, brass, and tinned metals (used with the copper bit or blowpipe) |
| Tallow (without salt) | Lead, tin, or tinned metals (used with the blowpipe or wiping process) |
| Sal ammoniac | Copper, brass, and iron (used with the copper bit or blowpipe) |
| Muriatic, or hydrochloric, acid | Dirty zinc (used with copper bit) |
| Chloride of zinc | Clean zinc, copper, brass, tin, and tinned metals (used with copper bit or blowpipe) |
| Rosin and sweet oil | Lead and tin tubes (used with copper bit or blowpipe) |
| Borax | Iron, steel, copper, and brass (used with blowpipe) |

to get up the heat in the pipe, and when the joint is finished the metal will appear chalky and porous.

**5. Fluxes.**—In order to aid the fusion of solder and to clean the surface of the metals to be joined, and thus promote the adhesion of the melted solder, *fluxes* are used. Table II gives some of the most common fluxes and the metals they are chiefly used upon.

**6. Chloride of zinc,** or what is commonly called by the trade *reduced acid,* is prepared by mixing hydrochloric acid, sometimes called muriatic acid, with zinc, which is in the form of grains, chips, or strips. The acid should be placed in an earthenware vessel out of doors and the zinc added. The acid and zinc rapidly combine, and during the process a quantity of gas is disengaged, which causes the liquid to boil and emit copious fumes, which are very corrosive; considerable heat is also generated. If desired, the acid may be diluted with water to reduce the strength of the solution. When the liquid stops boiling or giving off bubbles of gas and some of the zinc is still undissolved, the acid is *saturated;* that is, it has dissolved all the zinc that it is capable of holding in solution and it is ready for use.

Chemically pure muriatic acid is as clear as water, while the commercial acid is yellow, on account of impurities it contains, such as iron, arsenic, or organic matter. The commercial acid is good enough to use in making the chloride-of-zinc flux for tinning and soldering purposes.

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## MISCELLANEOUS MATERIALS

**7. Oakum** is composed of fibers of hemp, which are made to adhere strongly together by moistening them with pine tar. It can be obtained in bales, and the oakum is either loose or slightly twisted.

**8. Asphaltum** is a native mineral pitch or bitumen. It is black or dark brown in color and has a high luster on its fractured surfaces. Its specific gravity is about 1.1. It melts, and burns leaving no residue, and dissolves completely in petroleum or turpentine. For the purpose of making waterproof coatings on brickwork, etc., it is mixed with coal tar and applied while hot. It is used for coating all kinds of ironwork that is exposed to dampness or is to be buried in soil. To obtain the most complete protection in such cases, pipes, etc., that are to be thus coated should be heated to the melting point of the asphaltum before they are dipped.

**9. Plaster of Paris** is used in the plumbing trade chiefly for bedding or setting marble work, making joints about wash basins, cocks, etc. It should be mixed in small quantities with water to the consistency of thick cream, and should be applied as quickly as possible, for it sets rapidly; it should not be disturbed while setting. Plaster of Paris is very porous and therefore not suitable for making joints under water. If plaster of Paris begins to set while being applied, it should be thrown away and a fresh batch mixed. No attempt should be made to thin it with water.

**10. Portland cement** is used by plumbers for many purposes, chiefly for joining earthenware pipes. Before using, it should be mixed with an equal quantity of clean, sharp sand and then tempered with clean water into a thick mortar. If too much cement is mixed at a time, it will begin to set before it can be applied. Portland cement should not be *tempered,* that is, thinned with water, when it has begun to harden, for any purpose except for bedding or supporting fireclay pipes. This cement will set under water; a barrel of it weighs about 400 pounds.

**11. Rosendale cement** is similar to but not of so high a quality as Portland cement. Before being tempered with water, it should be mixed with sand in the same manner as is Portland cement. It is not suitable for joining fireclay pipes or other work under water. A barrel of Rosendale cement weighs about 300 pounds.

**12. Glaziers' putty** is made by mixing about seven parts of whiting with three parts, by weight, of boiled linseed oil. It is used for bedding woodwork around fixtures, for bedding cast-iron sinks, etc.

**13. Red lead** is mainly oxide of lead and is sold in kegs in the form of a heavy powder. It is prepared for use by mixing it in small quantities with boiled linseed oil just before using. It becomes very hard in setting, and is used to bed fixtures, set slate slabs, etc., but must not be used with marble.

**14. White lead** is a carbonate of lead ground to a fine paste, with boiled linseed oil. It is the basis of nearly all good house paints and is used for the same purposes as red lead.

**15. Plumbers' soil** is made of lampblack, water, and glue. Most plumbers prefer to buy the prepared soil from plumbers' supply houses, but some make it themselves. To make plumbers' soil, a package of lampblack is mixed in a mortar with water, while 1 tablespoonful of good glue is being heated in about 1 quart of water. When the glue is melted, the lampblack is poured in, and the mixture stirred while boiling for about 1 hour. A piece of sheet lead should then be painted with the soil and allowed to dry. If, when the lead is bent back and forth, the soil cracks, it contains too much glue; if it rubs off with the hand, more glue is needed. When cold, the soil should have the consistency of gelatine. It must always be melted with heat before it is applied with the brush.

**16. Plumbers' paste** is a mixture of water and flour that has been cooked until it has the consistency of jelly. In hot weather, a little alum, blue vitriol, or carbolic acid may be added to prevent the mixture from becoming sour. This paste is used for pasting paper around joints. Prepared paste for wiping joints can be bought from supply houses; it is used like soil, and can be washed off after the joint is made.

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## RIVETS

**17. Rivets** for plumbers' use are made chiefly of wrought iron and copper. Iron rivets without coating are called *black rivets,* and when coated with tin, are known as *tinned rivets.* The *button head,* or *cup,* rivet *a,* Fig. 4, is used for joining relatively thick sheets, particularly if they are subjected to internal pressure, or where the riveted seam must be water-tight, as in an ordinary kitchen boiler. The most common form of rivet used in the trade is the common *flat-head* rivet *b.* This form is used on all classes of thin sheet-iron work. The *countersunk-head* rivet *c* is used only in joining thick sheets

or plates, or other work, where the rivet head is to be finished flush with the material riveted. The *braziers'* rivet *d* is made of copper and is used chiefly on sheet-brass or sheet-copper work. The *burr e* is generally employed with the copper rivet, the burr being placed on the end opposite the rivet head. The

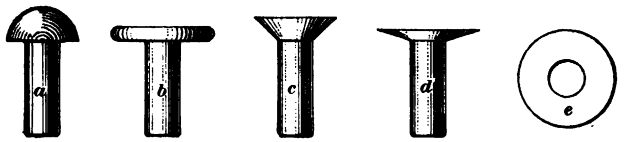


FIG. 4

object of using the burr is to distribute over a large surface the stresses due to the riveting, and thus to avoid cracking the sheet and to prevent it from bulging between the rivets. Small rivets are put up in packages of 1,000, and their size is designated by the weight of the package in ounces or pounds.

## PIPES

### LEAD PIPE

**18.** The best quality of lead pipe is made from pure virgin, refined pig lead. Lead pipe made from scrap or old lead that has already been used, will not be as good and will not carry as high a pressure as pipe made from virgin metal. Lead pipe in the smaller sizes is better adapted for conveying water from the street main to water tanks, house supplies, etc., and for these purposes the grade known to the trade as *3A* should be used.

Lead pipe is not as durable for hot-water lines as for cold; for the modern hot-water heating apparatus heats the water so quickly and to such a high temperature that the life and flexibility of the lead pipe are soon destroyed, as the expansion when heating and the contraction when cooling are not equalized. Where there is an extremely high temperature, the pipe will crystallize and the joints will eventually pull apart and leak.

Lead pipe should not be used for range connections. Work of this character has been or should be entirely discontinued and the more substantial brass connections used. Lead pipe is made by the die-and-press process, so that the pipe is seamless. Formerly plumbers made the larger sizes of pipes from sheet lead, but by the use of special dies they are now made of any size that is in general use. The sizes used for water supplies, etc., are shown in Table III. The sizes of lead pipe smaller than those shown in the table are known as *lead tubing;*

### TABLE III

**WEIGHT OF 1 FOOT OF LEAD PIPE AND TIN-LINED LEAD PIPE**

| Inside Diameter Inches | AAA Brooklyn | | AA Extra Strong | | A Strong | | B Medium | | C Light | | D Extra Light | | E Fountain | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lb. | Oz. | Lb. | Oz. | Lb. | Oz. | Lb. | Oz. | Lb. | Oz. | Lb. | Oz. | Lb. | Oz. |
| $\frac{3}{8}$ | 1 | 12 | 1 | 8 | 1 | 4 | 1 | 0 | | 12 | | 10 | | 7 |
| $\frac{7}{16}$ | | | | | | | 1 | 0 | | 13 | | | | |
| $\frac{1}{2}$ | 3 | 0 | 2 | 0 | 1 | 12 | 1 | 4 | 1 | 0 | | 12 | | 9 |
| $\frac{5}{8}$ | 3 | 8 | 2 | 12 | 2 | 8 | 2 | 0 | 1 | 8 | 1 | 0 | | 12 |
| $\frac{3}{4}$ | 4 | 12 | 3 | 8 | 3 | 0 | 2 | 4 | 1 | 12 | 1 | 4 | 1 | 0 |
| 1 | 6 | 0 | 4 | 12 | 4 | 0 | 3 | 4 | 2 | 8 | 2 | 0 | 1 | 8 |
| $1\frac{1}{4}$ | 6 | 12 | 5 | 12 | 4 | 12 | 3 | 12 | 3 | 0 | 2 | 8 | 2 | 0 |
| $1\frac{1}{2}$ | 8 | 8 | 7 | 8 | 6 | 8 | 5 | 0 | 4 | 4 | 3 | 8 | 3 | 0 |
| $1\frac{3}{4}$ | 10 | 0 | 8 | 8 | 7 | 0 | 6 | 0 | 5 | 0 | 4 | 0 | | |
| 2 | 11 | 12 | 9 | 0 | 8 | 0 | 7 | 0 | 6 | 0 | 4 | 12 | | |

the sizes and weights of 1 foot, the sizes being inside diameter, are as follows: $\frac{1}{16}$ inch, $\frac{3}{4}$ ounce; $\frac{1}{8}$ inch, $1\frac{1}{4}$ ounces; $\frac{5}{32}$ inch, $2\frac{1}{4}$ ounces; $\frac{1}{4}$ inch, 5, 6, 8, or 13 ounces.

Lead pipe is shipped in coils, the lighter, or waste, pipe being protected with straw rope so that the pipe will not be injured during shipment; sometimes it is coiled on a wooden spool, like thread. The latter method effectually protects the pipe during shipment and while the coil is being unrolled.

The smaller sizes of lead pipe, up to $\frac{3}{8}$-inch, may be obtained in coils containing up to 200 feet or over; the next sizes, up to

¾-inch, in coils averaging 65 feet. The larger sizes, including 1-inch, 1½-inch, and 2-inch, may be had in any desired lengths by special order to the manufacturer.

### TABLE IV
#### LEAD WASTE PIPE

| Inside Diameter Inches | Weight of 1 Linear Foot Pounds | Inside Diameter Inches | Weight of 1 Linear Foot Pounds |
|---|---|---|---|
| 1¼ | 1½ to 2½ | | |
| 1½ | 2½ to 3 | 4 | 5 to 8 |
| 2 | 3½ to 4 | 4½ | 8 to 10 |
| 2½ | 4 to 6 | 5 | 8 to 12 |
| 3 | 4½ to 6 | 6 | 12 and up |

**19.** The larger sizes of lead pipe, commonly called *waste pipes,* are much thinner in proportion to their diameter than the smaller ones, because the small pipes are intended to convey water under pressure, while waste pipes convey water at atmospheric pressure only. The weights and standard sizes of of lead waste pipe are given in Table IV. Owing to the comparative thinness of the larger sizes of waste pipes, they cannot be coiled upon reels like the water pipes; and as they are easily injured, they must be boxed and shipped as straight tubes. The length of each tube is usually about 10 feet.

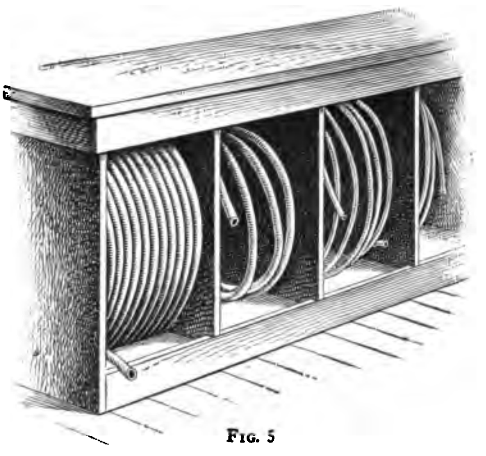

Fig. 5

In order properly to protect lead pipe in coils against injury in the shop or store, and also as a convenient method of storage,

## TABLE V

### APPROXIMATE PRESSURE PER SQUARE INCH AT WHICH LEAD PIPES WILL BURST

| Inside Diameter | Letter | Pounds per Square Inch | Inside Diameter | Letter | Pounds per Square Inch |
|---|---|---|---|---|---|
| 3/8 | AAA | 2,150 | 1 | AAA | 1,300 |
| 3/8 | AA | 2,000 | 1 | AA | 1,100 |
| 3/8 | A | 1,650 | 1 | A | 900 |
| 3/8 | B | 1,500 | 1 | B | 775 |
| 3/8 | C | 1,250 | 1 | C | 600 |
| 3/8 | D | 1,050 | 1 | D | 500 |
| 3/8 | E | 800 | 1 | E | 400 |
| 1/2 | AAA | 2,000 | 1 1/4 | AAA | 1,000 |
| 1/2 | AA | 1,600 | 1 1/4 | AA | 900 |
| 1/2 | A | 1,500 | 1 1/4 | A | 750 |
| 1/2 | B | 1,150 | 1 1/4 | B | 600 |
| 1/2 | C | 900 | 1 1/4 | C | 475 |
| 1/2 | D | 700 | 1 1/4 | D | 450 |
| 1/2 | E | 550 | 1 1/4 | E | 350 |
| 5/8 | AAA | 1,700 | 1 1/2 | AAA | 900 |
| 5/8 | AA | 1,500 | 1 1/2 | AA | 800 |
| 5/8 | A | 1,300 | 1 1/2 | A | 700 |
| 5/8 | B | 1,150 | 1 1/2 | B | 550 |
| 5/8 | C | 900 | 1 1/2 | C | 475 |
| 5/8 | D | 600 | 1 1/2 | D | 400 |
| 5/8 | E | 500 | 1 1/2 | E | 350 |
| 3/4 | AAA | 1,900 | 2 | AAA | 650 |
| 3/4 | AA | 1,400 | 2 | AA | 550 |
| 3/4 | A | 1,150 | 2 | A | 500 |
| 3/4 | B | 950 | 2 | B | 450 |
| 3/4 | C | 750 | 2 | C | 375 |
| 3/4 | D | 550 | | | |
| 3/4 | E | 450 | | | |

it should be kept in a rack, which may be constructed in any suitable manner. Fig. 5 shows a common form. Care must be taken in handling pipe so as not to flatten or bruise it in any way. Straight, thin lead pipe is best kept in long boxes.

**20.** Table V shows the pressures required to burst lead pipes of various sizes and qualities. The safe pressure for any of these pipes can be found by dividing the bursting pressure by a factor of safety of 5. For example, the bursting pressure of a $\frac{3}{8}$-inch AAA pipe is given as 2,150 pounds; therefore, such a pipe may be used where it is not expected that the pressure will be greater than $2{,}150 \div 5 = 430$ pounds per square inch. Conditions may in some cases permit the factor of safety to be reduced and in other cases to be increased.

### TIN PIPE

**21. Tin pipe** is made in a manner similar to lead pipe, but is composed of commercially pure tin. To distinguish it

### TABLE VI

#### PURE BLOCK-TIN PIPE

| Inside Diameter Inches | Weights per Foot |
|---|---|
| $\frac{3}{8}$ | 4, 5, 6, and 8 ounces |
| $\frac{1}{2}$ | 6, $7\frac{1}{2}$, and 10 ounces |
| $\frac{5}{8}$ | 8 and 10 ounces |
| $\frac{3}{4}$ | 10 and 12 ounces |
| 1 | 15 and 18 ounces |
| $1\frac{1}{4}$ | $1\frac{1}{4}$ and $1\frac{1}{2}$ pounds |
| $1\frac{1}{2}$ | 2 and $2\frac{1}{2}$ pounds |
| 2 | $2\frac{1}{2}$ and 3 pounds |

from common tin pipe, which is made of iron or steel covered with tin and is used for furnace pipes or speaking tubes, it is commonly called *block-tin pipe*. There are many inferior grades of this pipe, the tin in them being alloyed with cheaper

metals, such as lead and zinc. A high grade of tin pipe should shine like silver, if polished, and even the coil, no matter how old, should be white, but not of a bluish tint. If a piece of genuine tin pipe is bent, it produces a crackling sound; lead pipe or tin pipe heavily alloyed does not make this noise.

**22.** Block-tin pipe is used principally for conveying beer, ales, and spirituous liquors; also rainwater, condensed water, or other pure waters, etc., which oxidize or otherwise affect lead. The standard sizes and weights of block-tin pipe are given in Table VI; other sizes and weights are made to order. From the table, it will be seen that each size of block-tin pipe is made in different weights per foot; therefore, since the different weights are not designated in any other way, it is necessary to specify both diameter and weight per foot when ordering.

### COMPOSITION PIPE

**23. Composition pipe** is made from a mixture of block tin, lead, zinc, and presumably other similar materials that can be used without materially injuring the pipe. It is often used by mistake for block-tin pipe. It can be distinguished from block-tin pipe by the absence of the sharp, crackling sounds when it is bent, and by its bluish tinge. In color it is about midway between lead and tin, and it is shipped in coils like block-tin pipe. Composition pipe is used only for special purposes.

### TIN-LINED PIPE

**24. Tin-lined lead pipe** is a lead pipe with a block-tin lining fused to the lead. The construction is as shown in Fig. 6. Tin-lined pipe has the advantages of block-tin pipe, and, being much cheaper, the tin-lined pipe is used to a large extent as a substitute for the other. The value of tin-lined pipe is determined by the thickness of the lining, which ordinarily is about $\frac{1}{16}$ inch thick. Extra-heavy lining can be had by ordering it from the jobber or manufacturer. Tin-lined pipe can be distinguished from block-tin pipe by the absence

of the crackling sound when it is bent, and it is usually made with two small ridges, or ribs, running its full length, as shown at *a* in Fig. 6. It is more easily soldered than block-tin pipe, as it is less likely to melt at contact with the soldering bit.

Fig. 6

**25. Tin-lined iron pipe** is plain iron or steel pipe coated inside with block tin. In the best kind, the lining is fused to the iron. Care must be taken in cutting and threading such pipe not to mar the lining, also the exposed ends where the pipe is cut must be carefully tinned, and all fittings such as elbows, T's, couplings, etc., which are used with such pipe must be tin-lined, so that the bare iron will in no case be exposed to the action of the fluid in the pipe.

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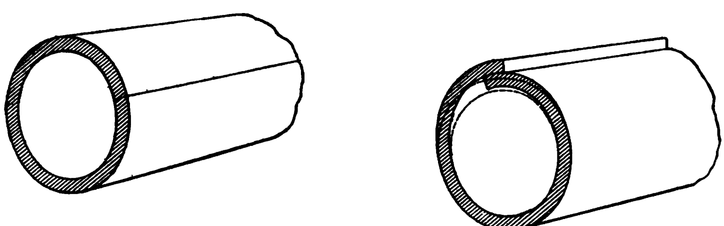
### WROUGHT PIPE

**26.** The term **wrought pipe** is applied to pipe made of mild, or soft, steel. Such pipe should not be confused with **wrought-iron pipe,** which closely resembles the wrought pipe but is more costly and is used only when definitely called for by specifications. Wrought pipe is used black, as it is first made, or it may be galvanized; that is, coated with zinc. The dimensions given in Table VII are conformed to by all


(*a*) (*b*)
Fig. 7

American manufacturers. Wrought pipes are made in lengths of about 15 to 20 feet. All pipe that is $1\frac{1}{4}$ inches or less in

diameter is *butt-welded;* that is, the edges are joined as shown in Fig. 7 (*a*). Large sizes are usually *lap-welded,* the edges being lapped as shown in (*b*). All butt-welded pipe is tested at the mills to a pressure of at least 300 pounds a square inch; the pressure applied to test lap-welded pipe is 500 pounds a square inch. Wrought pipes having a greater thickness of metal than those mentioned are known as *extra strong* and *double extra strong;* the extra thickness of metal, however,

### TABLE VII

#### STANDARD DIMENSIONS OF WROUGHT PIPE

| Nominal Internal Diameter Inches | Actual Internal Diameter Inches | Actual External Diameter Inches | Thickness of Metal Inches | Area of Internal Diameter Square Inches | Weight per Linear Foot Pounds |
|---|---|---|---|---|---|
| $\frac{1}{8}$ | .270 | .405 | .068 | .0572 | .243 |
| $\frac{1}{4}$ | .364 | .540 | .088 | .1041 | .422 |
| $\frac{3}{8}$ | .494 | .675 | .091 | .1916 | .561 |
| $\frac{1}{2}$ | .623 | .840 | .109 | .3048 | .845 |
| $\frac{3}{4}$ | .824 | 1.050 | .113 | .5333 | 1.126 |
| 1 | 1.048 | 1.315 | .134 | .8627 | 1.670 |
| $1\frac{1}{4}$ | 1.380 | 1.660 | .140 | 1.4960 | 2.258 |
| $1\frac{1}{2}$ | 1.610 | 1.900 | .145 | 2.0380 | 2.694 |
| 2 | 2.067 | 2.375 | .154 | 3.3550 | 3.667 |
| $2\frac{1}{2}$ | 2.468 | 2.875 | .204 | 4.7830 | 5.773 |
| 3 | 3.067 | 3.500 | .217 | 7.3880 | 7.547 |
| $3\frac{1}{2}$ | 3.548 | 4.000 | .226 | 9.8870 | 9.055 |
| 4 | 4.026 | 4.500 | .237 | 12.7300 | 10.728 |
| $4\frac{1}{2}$ | 4.508 | 5.000 | .246 | 15.9610 | 12.492 |
| 5 | 5.045 | 5.563 | .259 | 19.9900 | 14.564 |
| 6 | 6.065 | 6.625 | .280 | 28.8890 | 18.767 |

reduces the bore of the pipe, for the outside diameter of each nominal size is never changed. Thus, all grades of wrought or iron pipe will connect properly with standard fittings.

Either wrought or wrought-iron pipes are easily threaded by means of proper dies. The sizes from $\frac{1}{8}$ to $1\frac{1}{4}$ inches are threaded on both ends at the factory and a socket, or coupling, is placed on each piece; the pipes are then packed in bundles for shipment The larger sizes of pipe are threaded on both ends, and the ends are protected by sleeves or sheet-iron

casings. Large sizes of pipe can be ordered cut and threaded to measurement. All pipe when stored should be protected from the weather.

**27. Lead-lined iron pipe** is ordinary iron or steel pipe lined with lead. Such pipe is particularly valuable for carrying acid-bearing mine water, salt water, or any water that will corrode plain or galvanized iron or steel pipe. Cast-iron soil pipe, lead-lined as shown in Fig. 8, (*a*) is used where the pipe is required to withstand the action of acids or other chemicals,

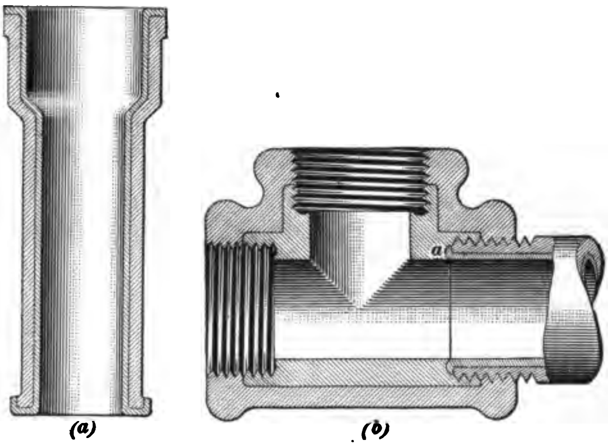



Fig. 8

as in experimental stations, laboratories, etc. Brass, copper, or iron pipe of any kind can be obtained lead-lined or lead-covered from the manufacturers.

The lining should not be less than ⅛ inch thick for ordinary pipes and the lead should be fused to the iron. If this is not done, the water may get between the lining and the pipe, and the lining will be of no effect. The cut ends of the pipe should be tinned, as was explained for tin-lined iron pipe, and all the fittings should be lead-lined; also, when the fittings are screwed to the pipe, the lead linings should butt end to end, as shown at *a* in Fig. 8 (*b*). If bends, instead of elbows, are to be used, it is better to order them from the manufacturers, so that the linings will not be damaged in making the bends.

### BRASS AND COPPER PIPE

**28.** There are two kinds of brass and copper pipes: one kind, called *seamless drawn tubing,* is made from a solid block of metal and is without a joint; the other, called *brazed tubing,* is similar in structure to butt-welded wrought pipe, except that the joint is secured by brazing. The seamless drawn tubing is much better than the brazed tubing and is the kind that should be used for plumbing work.

There are many sizes and thicknesses of such pipe. The sizes commonly used by plumbers have the same outer

### TABLE VIII

SEAMLESS-DRAWN BRASS AND COPPER TUBES—IRON-PIPE SIZE

| Iron Pipe Sizes Inches | Actual Outside Diameter Inches | Actual Inside Diameter Inches | Approximate Weight of 1 Foot Pounds* | Iron Pipe Sizes Inches | Actual Outside Diameter Inches | Actual Inside Diameter Inches | Approximate Weight of 1 Foot Pounds* |
|---|---|---|---|---|---|---|---|
| $\frac{1}{8}$ | .405 | .281 | .25 | $2\frac{1}{2}$ | 2.875 | 2.5 | 5.75 |
| $\frac{1}{4}$ | .540 | .375 | .43 | 3 | 3.500 | 3.062 | 8.30 |
| $\frac{3}{8}$ | .675 | .494 | .62 | $3\frac{1}{2}$ | 4.000 | 3.5 | 10.90 |
| $\frac{1}{2}$ | .840 | .625 | .90 | 4 | 4.500 | 4.0 | 12.70 |
| $\frac{3}{4}$ | 1.050 | .822 | 1.25 | $4\frac{1}{2}$ | 5.000 | 4.5 | 13.90 |
| 1 | 1.315 | 1.062 | 1.70 | 5 | 5.563 | 5.062 | 15.75 |
| $1\frac{1}{4}$ | 1.660 | 1.368 | 2.50 | 6 | 6.625 | 6.125 | 18.31 |
| $1\frac{1}{2}$ | 1.900 | 1.6 | 3.00 | 7 | 7.625 | 7.062 | 23.73 |
| 2 | 2.375 | 2.062 | 4.00 | 8 | 8.620 | 7.980 | 29.88 |

*Copper tubes weigh 5 per cent. more than brass tubes of corresponding size.

diameters as wrought pipe and can be cut and threaded with the same dies. Such pipe is designated as being of *iron-pipe size,* and fittings are made to correspond. Various thicknesses of brass and copper pipe are made; therefore a thickness suitable to the work to be done must be specified when the

pipe is ordered. The market sizes of seamless drawn brass and copper pipe are given in Table VIII.

Brass and copper pipes, when used to carry water for drinking purposes, should always be tinned on the inside, otherwise the water may be poisoned to a serious extent. Brass pipe for plumbing work should always be annealed or semiannealed, otherwise it is liable to crack, especially on cold-water lines. The experienced plumber will know how to order brass pipe suitable for the purpose intended; the inexperienced plumber should consult the manufacturers in order to avoid the danger of loss from using material unsuited to the purpose for which it is used.

**29.** Brass pipes, tubing, and fittings used in exposed plumbing in bathrooms, kitchens, etc., are, as a general rule, nickel-plated, which gives them a fine finish, and when shipped

TABLE IX

PLUMBERS' SEAMLESS-DRAWN BRASS TUBES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Outside diameter, inches | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ | 1 | $1\frac{1}{4}$ | $1\frac{1}{2}$ | $1\frac{3}{4}$ | 2 |
| Stubs' gauge, thickness. | 15 | 15 | 15 | 14 | 13 | 13 | 13 | 13 |
| Weight of 1 foot, pounds | .46 | .56 | .67 | .88 | 1.27 | 1.55 | 1.82 | 2.10 |

to their destination, are carefully wrapped so as to avoid scratching and tarnishing. The plumber, in installing such pipes must be careful in putting them together and use only tools specially adapted for the purpose. Plain brass pipe is shipped in bundles in the same manner as iron pipe and is not threaded. Brass pipe, iron-pipe size, semiannealed, tinned inside and outside, is used extensively in the very finest class of work.

Plumbers' seamless-drawn brass tubes are made thinner than drawn tubing of iron-pipe sizes, and are designated by their outside diameter. Pipes of this kind require special fine-thread dies to thread them. Brass tubing can be furnished in lengths from 12 feet to 16 feet, annealed or semiannealed. Table IX gives the sizes of tubes usually carried in stock by supply houses.

### CAST-IRON PIPES

**30.** Cast-iron pipes used by plumbers for house drainage are known to the trade as **cast-iron soil pipe;** those used for outside pressure work are *cast-iron gas pipes* and *cast-iron*

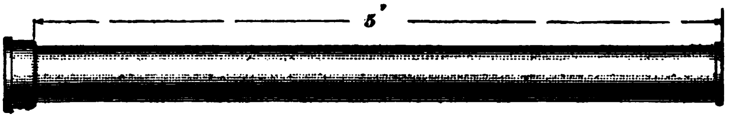



FIG. 9

*water pipes*. Soil pipe is made in three grades, known as *standard, medium,* and *extra-heavy*. The use of standard pipe is not to be recommended, as it is likely to split, corrode, and break at the hub at the least strain. Its use is prohibited in most cities and towns that have a health department. Medium soil pipe, being heavier than standard pipe, is better and is extensively used. Extra-heavy soil pipe is the best to use for plumbing purposes, as by its use the danger of cracks, flaws, and breakage is to a great extent avoided.

**31.** Cast-iron soil pipes are made in the form shown in Fig. 9 in 5-foot lengths, exclusive of the socket, and in sizes from 2 to 15 inches inside diameter; they are sold by the linear foot. A double-hub pipe has a hub, or socket, on each end, but, as shown in Fig. 10, one of the hubs is measured into the 5-foot length. By use of such pipe it is possible to avoid waste when pipes must be cut to length. For example, if a piece 3 feet 6 inches long is cut from a 5-foot length of double-hub pipe, the remaining piece, 1 foot 4 inches long, exclusive of the hub, will have a socket on one end and can be used in

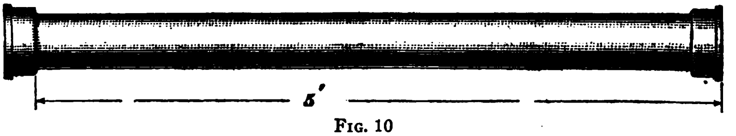



FIG. 10

some place where a pipe of that length is required. If the piece had been cut from a pipe like that shown in Fig. 9, the remaining piece would have no socket on it and the only way

it could be used would be to calk a double-hub fitting on the end of it, and as this would require time, oakum, and lead, it might be cheaper to throw the piece away. Therefore, when ordering pipe for a job, the plumber should include enough double-hub pipe so that there will be no waste of time or material in making up the desired lengths. The employer judges a plumber by his ability to economize on material and time as well as by his workmanship, and a good workman rarely has any junk to be returned to the shop.

**32.** The best pipes, generally speaking, are those that are cast vertically, because their thickness is more uniform all around and the iron is more easily cut. Pipes cast horizontally have a rib on opposite sides running full length, which shows where the halves of the mold join.

Cast-iron pipes may be plain, that is, as they come from the mold, or coated with asphaltum or some other material especially adapted to protect iron against corrosion. When soil pipe is ordered, it is necessary to specify whether plain or coated pipe is desired. Some city health and plumbing codes prohibit the use of coated pipe; for the reason that imperfections, such as sand holes, fine cracks, or flaws in the casting are covered by the coating and are not readily detected by air and water tests.

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### EARTHENWARE PIPES

**33. Earthenware, or terra-cotta pipes,** as they are often called, are made of various kinds and qualities of clay, in 2-foot and 3-foot lengths, and are provided with a socket on one end, while the other end is plain. These pipes are baked hard and are made impervious to water by a coating of salt glaze. They are also known as *vitrified,* or *tile, pipes.*

Vitrified earthenware pipes are commonly used for underground, but never for inside, drainage. The sizes usually kept in stock by dealers are 3, 4, 5, 6, 7, and 8 inches inside diameter. Perfect pipes are straight, cylindrical in form, smooth inside, and have no kiln cracks back of the hub or elsewhere.

## PIPE FITTINGS

### GAS- AND WATER-PIPE FITTINGS

**34.** Figs. 11 and 12 show an assortment of malleable-iron **pipe fittings.** These can be had *beaded* or *plain*, and some of either kind are shown. The beaded fittings are the strongest and best, for the bead, which will be noticed around the outside edges of the threaded openings, is a reinforcement that prevents the fitting from being split when the tapered thread

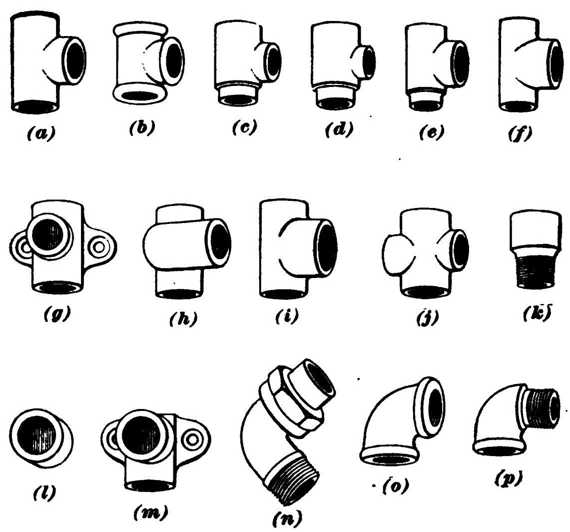


FIG. 11

is screwed into it. Their use is recommended. The plain fittings have about the same thickness in every part.

**35.** The names of the different fittings, all those shown in Fig. 11 being for $\frac{3}{4}$-inch pipe, are as follows: View (*a*) shows a $\frac{3}{4}$-inch *plain* **T**, or *tee;* that is to say, it has a $\frac{3}{4}$-inch straight run and a $\frac{3}{4}$-inch branch. The *run* of a **T** is the line through the largest opposite openings; the other openings are the *branches.* In the case of crosses, the run is always considered

to be the line through the largest opposite openings. When ordering **T**'s and crosses, the size of the run must always be given first, then the size of the branches; this will prevent confusion in filling the orders. View (*b*) represents a ¾″×¾″×½″ *beaded* **T**; that is, it has a ¾-inch run and a ½-inch branch.

An illustration of a ¾″×½″×½″ *reducing plain* **T** is shown in view (*c*). It is used to connect two ½-inch pipes and a ¾-inch pipe, the run being reduced from ¾ to ½ inch. A ¾″×½″×⅜″ reducing plain **T** is shown in view (*d*).

View (*e*) shows a ½″×⅜″×¾″ *bullhead* **T**; view (*f*) illustrates a ½″×¾″ *plain bullhead* **T**.

In view (*g*) is shown a ¾″×½″ *drop* **T** which has two lugs, one on each side of the run, by which the fitting is screwed to the wall. It takes its name from the drop fittings so commonly used in gas-pipe work.

In view (*h*) is shown a ¾″×¾″ *plain cross-over* **T**, used where a branch has to cross over the top of another pipe. This fitting is used to a great extent for wash-tray fittings as the eccentric allows one pipe to pass another without interference.

View (*i*) shows a ¾″×1″ plain bullhead **T**, used to screw on the end of a 1-inch pipe, which supplies two ¾-inch branches at right angles. View (*j*) represents a ¾″×½″ plain cross for a ¾-inch run and two ½-inch branches. If it had a ½ inch and a ⅜-inch branch, it would be known as a ¾″×¾″×½″×⅜″ reducing plain cross.

In view (*k*), a *plain extension piece* is illustrated. The upper end is tapped ¾ inch and the other end is threaded ¾ inch. The piece is used to extend a pipe just about the length of the thread.

View (*l*) is an illustration of a ¾-inch *plain cap*, used to close the end of a pipe by screwing over it. View (*m*) shows a ¾-inch *plain drop* **L**, commonly used over a sink at the back of the faucets, the lugs being screwed to the wall to secure the faucets, or for other work.

View (*n*) shows a *boiler coupling;* the male end screws into the boiler, and the female end attaches to the piping. A washer is used between the faces of the union, to make a tight

joint when the hexagon coupling ring shown is screwed up. This type is being gradually done away with and the ground-joint brass boiler coupling used in its place.

View (*o*) represents a $\frac{3}{4}$-inch ***beaded quarter* L,** or ***elbow,*** called a ***quarter*** because it is a right angle, or the fourth part of a circle. In view (*p*) a ***beaded street* L,** of which one end is threaded male and the other female, is illustrated.

**36.** In Fig. 12 (*a*), is shown a $\frac{3}{4}'' \times \frac{1}{2}''$ ***plain reducing* L.** In (*b*) a $\frac{3}{4}$-inch ***eighth beaded* L,** called ***eighth*** because it bends 45°, or one-eighth of a circle. View (*c*) shows an ***offset***

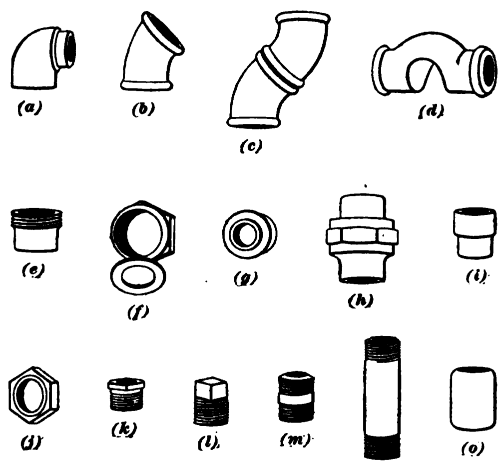

FIG. 12

formed by screwing two $\frac{3}{4}$-inch beaded eighth L's together with a close nipple between. A *close nipple* has the two threads run so closely together as to touch, allowing the fittings to come together, shoulder to shoulder, as shown. View (*d*) shows a $\frac{3}{4}$-inch *beaded straight cross-over* for use on a straight line of pipe where it crosses over another pipe.

In (*e*), (*f*), and (*g*) are shown parts of a $\frac{3}{4}$-inch ***plain union,*** which is shown assembled in (*h*). View (*e*) shows the threaded half of the union, while view (*g*) shows the half having a shoulder. The hexagonal *coupling ring* shown in (*f*) is slipped over the part shown in (*g*), and screws on the thread

of the part shown in (*c*), when the two halves are put together. A rubber washer, shown beneath the coupling ring, which fits over the shoulder, is placed between the two halves and is compressed by screwing up the coupling ring, thus making a tight joint.

Fig. 12 (*i*) shows a ¾″×½″ *plain reducing socket,* used to reduce ¾-inch pipes to ½ inch on a straight run.

A ¾-inch *hexagonal locknut,* shown in (*j*), is used for screwing over a long thread and making tight connections to a tank, one locknut being outside and one locknut inside the tank, with gaskets between them and the sides of the tank; and for other work.

In (*k*) is an illustration of a ¾″×½″ *bushing* having a hexagonal shoulder. The male thread is ¾ and the female thread ½ inch; this bushing is used to reduce a tapped opening so as to adapt it to fit a smaller pipe.

View (*l*) illustrates a ¾-inch *plug* that has a square head; it is used for closing a tapped opening.

In view (*m*) is shown a ¾-inch *shoulder nipple,* which is a piece of straight pipe having a tapered thread on each end, with a short space between the threads; it is used for joining two fittings together at close quarters. A common ¾-inch *nipple,* which is only a little longer than the shoulder nipple, is shown in (*n*).

View (*o*) shows a ¾-inch *plain coupling,* which is tapped in both openings, and is used for joining two ¾-inch pipes that are on a straight line.

**37.** Cast-iron fittings threaded for wrought-iron and wrought pipes are generally used for steam-heating and hot-water-heating systems. They are provided with especially heavy beads or bands, because cast iron is a much weaker metal than malleable iron when subject to tension, as is the case with fittings used for steam and hot-water systems.

**38. Unions** are made in many forms. They are used to join the ends of two pipes, neither of which can be turned, or to permit the disconnecting of the pipes at some future time without cutting them.

There are two kinds of unions. The *flanged union,* shown in Fig. 13, is used principally on wrought pipes having an inside diameter of 2 inches or more. The pipe ends *a* are screwed into the flanges *b*; the washer or gasket *c* is placed between the flanges and is then compressed by the nuts *d* when tightened. This action draws the flanges together and makes a water-tight joint. Care must be taken to have the flanges faced perfectly and the nuts screwed up equally, so that the pressure upon the washer will be uniform all around.

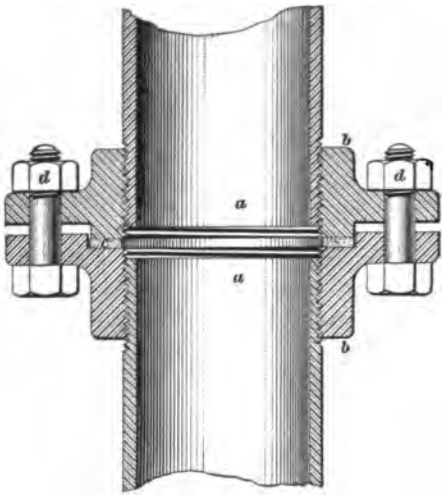

FIG. 13

**39.** The *screwed* unions are of two kinds. The *packed union* is shown in Fig. 12 (*e*), (*f*), (*g*), and (*h*). In the *ground unions,* shown in Fig. 14, the cone *a* and the socket *b* are ground to a

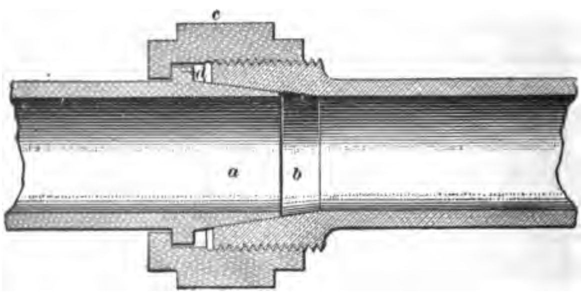

FIG. 14

perfect fit, and are drawn together by the nut *c*. The collar *d* must be turned true with the axis of the cone, and the axis of the screw thread must coincide perfectly with that of the cone, otherwise it will be difficult to draw the joint together with suf-

ficient accuracy to make a tight joint. The joint is made by the fit of the parts rather than by the pressure put upon them. Therefore, if the joint is not tight, it cannot be made so by straining the nut *c*; the fit of the parts must be rectified.

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### SOIL-PIPE FITTINGS

**40. Soil-pipe fittings** are made of cast iron, and are either provided with spigot and socket ends for connecting to cast-iron pipe by means of calked joints, or with threaded ends for connecting the wrought or steel drainage pipes by means of screwed joints. Common fittings that are kept in stock by plumbers' supply houses are shown in Figs. 15 to 19. The names printed under the fittings are their trade names. The abbreviation D. H. means double hub; R. H. means right hand; I. P. means iron pipe. Fittings for wrought or steel pipe, when used on sewer work, are always galvanized inside and outside. So many different fittings are manufactured that it is not possible here to show all those that can be used to advantage in the different classes of work. The fittings in general use are shown in the following pages. Some of those illustrated are shown merely for explanation. In making use of them, the plumber must be guided by his judgment and the rules and regulations under which he is working.

**41.** The tapped fittings shown in the top line in Fig. 15 are only a part of the numerous fittings made for venting purposes and need no explanation. The ¼ *bend* shown, which is commonly called an elbow, makes a bend of 90°, and is the fitting most commonly used. The ¼ *bend with side inlet* receives a branch in the curved portion, but makes a connection inferior to that made by a **Y**, or wye, branch. The ¼ *bend with heel outlet* should be used only when the branch can be placed vertically on top. The *long-sweep bend* should be used on all square turns, as it allows freer action and greater velocity for the liquid which passes through the pipe. The *long bend* is rarely used. The ⅕, ⅙, ⅛, and $\frac{1}{16}$ *bends* are occasionally called *obtuse* bends. Bends are designated by a com-

mon fraction in which the numerator is always 1, and the denominator shows the number of bends that, when placed together, form a complete circle. Thus, four $\frac{1}{4}$ bends, or six $\frac{1}{6}$ bends joined together complete the circle. The $\frac{1}{8}$ bend is the most commonly used obtuse bend.

The **T** and *long* **T** are useful for vent branches, but should not be used for pipes conveying liquid waste matter. The

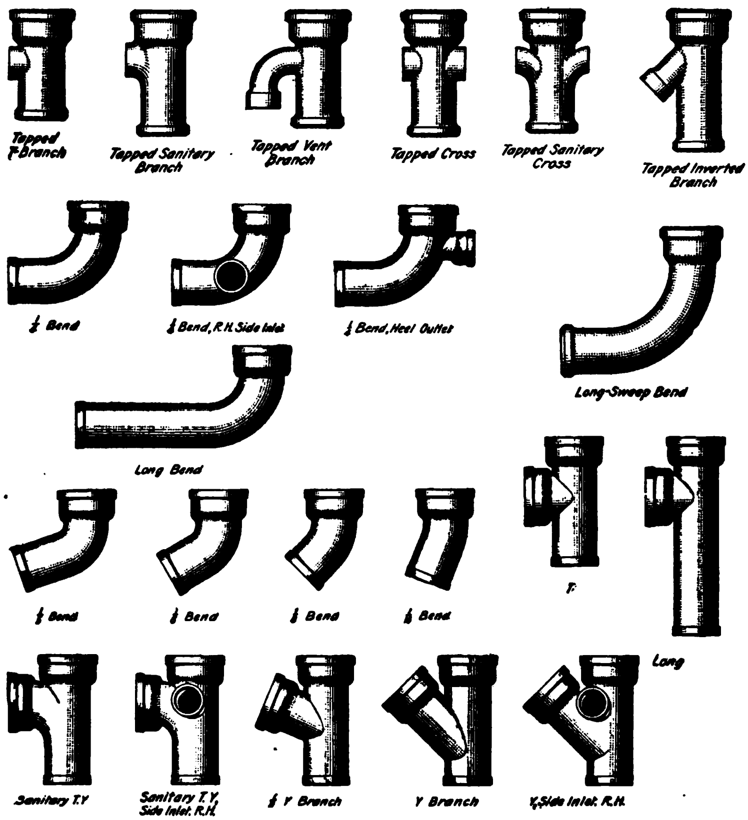



FIG. 15

*sanitary* **T Y** is a fitting which is half **T** and half **Y**; it often proves very useful in drainage work. It requires less space than a **Y** fitting, but the latter is superior from the sanitary standpoint. The *sanitary* **T Y** with side inlet has a 2- or 3-inch

socket, to which a bath or basin waste pipe may be connected, while the larger branch takes the water-closet waste pipe. The one-half Y branch is rarely used. In the Y branch, the branch makes an angle of 45° with the run. It is one of the best branch connections. The Y *side inlet* is used for the same purpose as the sanitary T Y, but is superior to it from the sanitary standpoint.

**42.** Special forms of cast-iron fittings are made for use as waste connections between water closets and stack lines; they may be obtained with or without side inlets. These fittings in many instances take the place of lead bends, especially when the floors are of cement concrete.

In Fig. 16 is shown a cast-iron closet bend with an adjustable collar *a* to permit of the proper adjustment of the height and of fastening the closet fixture to the drain. Inlets *b* are tapped, and to them may be connected bath or basin wastes or they may be used for venting the bend. The corrugations shown at *c* permit of cutting to any required length without danger of cracking the fitting if properly cut.

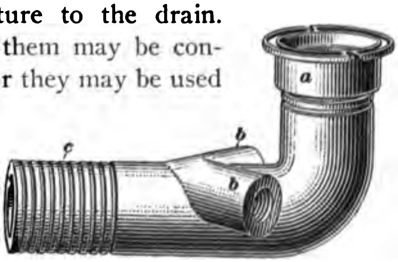


FIG. 16

**43.** In Fig. 17 the first three T's in the upper row are called Siamese-twin T's; they save much time and material where independent connections must be made to a stack and are insisted upon in many cities. Many other designs are also on the market. The *insertible joint*, Fig. 17, is convenient when a line of pipe must be cut into for putting in extra connections, etc. The *test* T is similar to the *cleanout* shown in lower right corner, except that the body is much larger to allow for the insertion of a testing plug; by using a *test* T the plumber can connect a line of soil pipe from the starting point outside of the wall and continue it to completion. The long Y branch shown is used for the same purpose as the Y branch illustrated in Fig. 15. The advantage of the long fittings is that they afford a better opportunity to calk and pack. The

*cross* is one of the most undesirable fittings and should never be used for sewage. The *double sanitary* **T Y**, the *double one-half* **Y**, and the double **Y** have two branches located opposite each other, as in the cross, but are far superior fittings, the

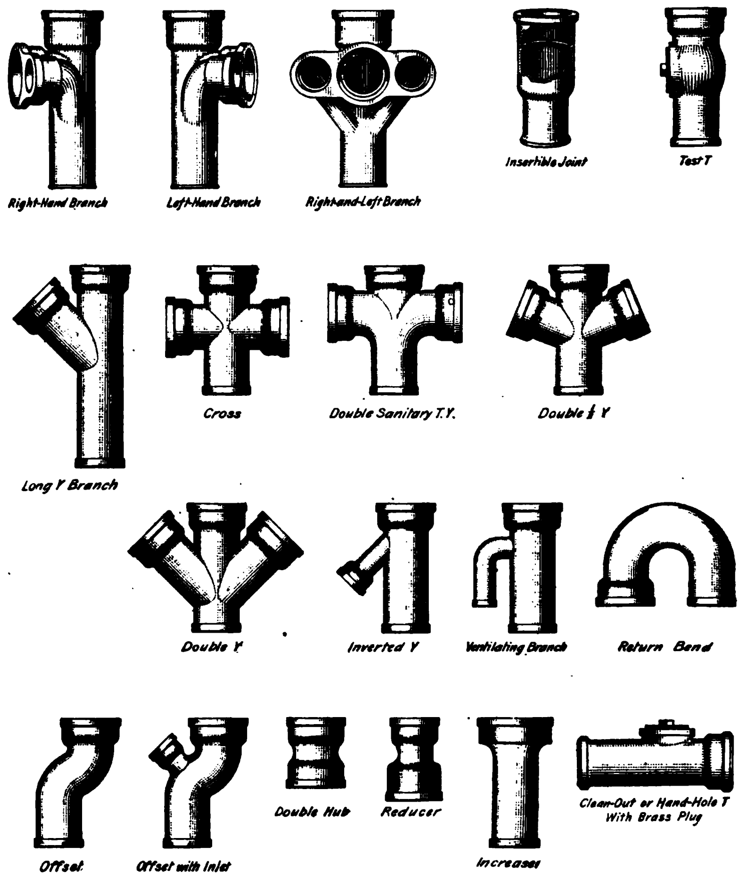



FIG. 17

double **Y** being the best. The *inverted* **Y** is used in vent pipes, where the direction of the current is upwards, for receiving a vent branch. The *ventilating branch* serves the same purpose as the inverted **Y**, but its lower end is more easily made tight by calking.

The *return bend* is used on top of fresh-air inlet pipes, or ventilating pipes, to prevent the admission of foreign matter to the drainage system. The *offset* is often needed to offset a soil pipe at the top of the cellar wall of frame buildings. Offsets are also made by using $\frac{1}{8}$ bends and a piece of pipe, an arrangement that is sometimes best adapted to the situation. The *offset with inlet* is used for the same purpose as the offset; it has a 2-inch socket to receive the waste branch from a sink,

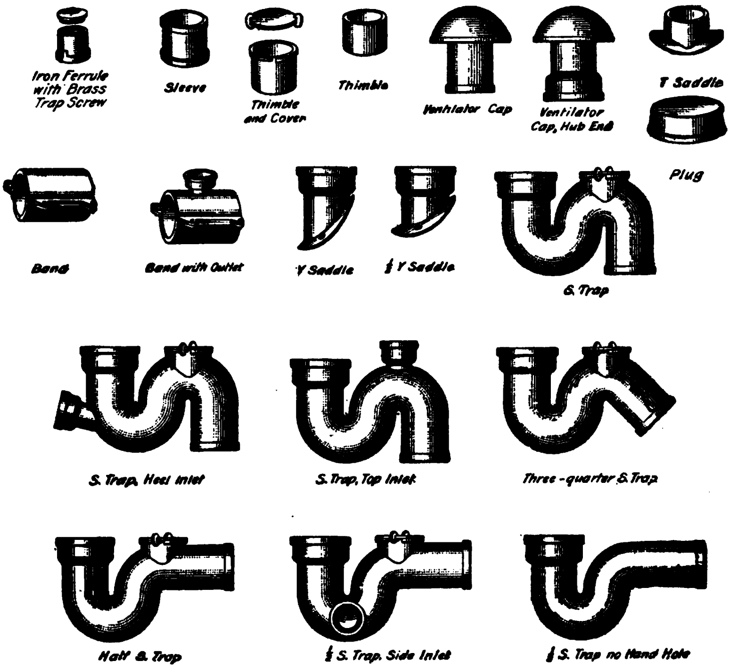



FIG. 18

etc. It would be much better, however, to put in a **Y** of the proper size below the offset, thereby eliminating all possible danger that the hub may break off from the offset.

The *double hub* is used for joining two pieces of pipe having no socket; it is never employed in good work. The *reducer* is often used in underground drainage work for reducing to a smaller size pipe. The *increaser* is used for increasing, and is often employed on soil pipes where they pass through the roof.

The *clean-out,* or *handhole,* **T** permits the line of pipe to which it is attached to be cleaned out. It should be put in wherever in the judgment of the plumber it may be necessary.

**44.** The *screw ferrule,* or *clean-out,* shown in Fig. 18 is used in traps, **T**'s, **Y**'s, or wherever it is necessary to put a clean-out. The *sleeve* is used to join the ends of two pieces of pipe that come together without a socket, as happens when a drain pipe is cut that a branch may be placed in it. The

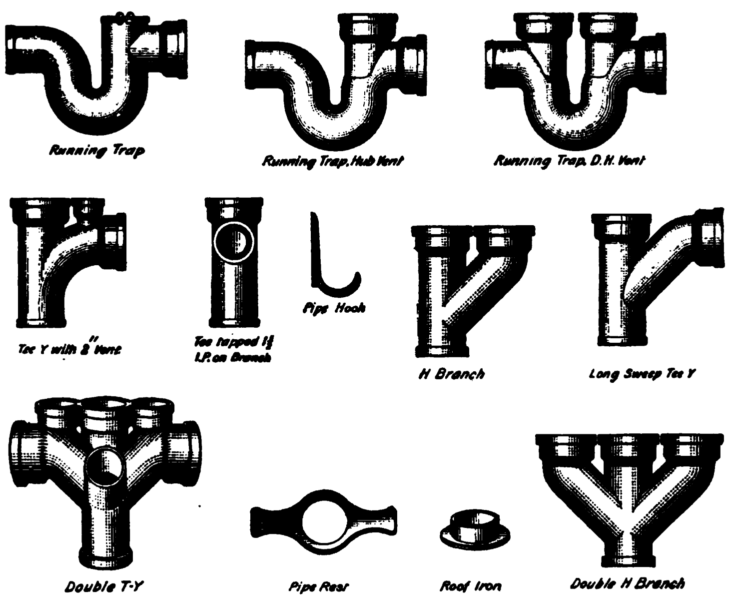



FIG. 19

*thimble and cover* is calked into a socket of a drain pipe to give admittance to the latter for cleaning out, but should never be used inside a building. The *thimble,* or *bushing,* is placed in a socket to reduce its size.

*Ventilator caps* are placed on the ends of fresh-air inlets and ventilating stacks to keep out foreign matter.

The **T** *saddle* is placed over a hole cut in a drain pipe to receive a branch. As the joint is made with putty, it should never be used inside a building and unless there is absolutely

no danger from sewer gas it should not be used at all. The *plug* is employed for closing the end of a pipe. The *band* is used for repairing a broken pipe or closing up a hole in it. The *band with outlet,* the **Y** *saddle,* and the *one-half* **Y** *saddle* are intended for making branch connections, but should never be used inside buildings, as the joint between them and the pipe to which they are attached does not remain gas-tight.

The **S** *trap,* the **S** *trap with heel inlet,* the *three-quarter* **S** *trap,* the *one-half* **S** *trap,* and the *one-half* **S** *trap with side inlet* here shown have a cleaning cap. As the joint between the cap and trap, which is made with putty, does not remain gas-tight, these traps are unsuitable for the inside of buildings. Where handholes are necessary on traps they should be of the hub pattern with screw ferrule calked in. The **S** *trap with top inlet* and the *one-half* **S** *trap, no handhole,* here shown have no putty joints, and hence are suitable for use inside buildings.

**45.** The *running trap* shown in Fig. 19 has a clean-out inlet and is suitable only for outdoor work. The *running traps with hub vent* and *double-hub vent* are suitable for inside work, the trap with double-hub vent being the more sanitary; because screw ferrules must be calked into hubs, so there would be no damage of sewer gas escaping into building.

The *pipe rest* is used to support pipes in a brick wall. The *roof iron* serves to make a neat joint where the soil pipe passes through the roof. The *pipe hook* is used to support soil pipes running along walls.

Other fittings manufactured to conform to the specifications of modern plumbing codes are: **T Y** *with vent,* **T** *tapped for iron pipe on branch,* **H** *branch, long sweep* **T Y**, *double* **T Y**, *double* **H** *branch.*

**46. Drainage fittings,** in a general way, are similar in form to those made of cast iron; but the ends, instead of a spigot and socket, are provided with threaded sockets into which the iron pipe is screwed. The ordinary pipe fittings used in steam fitting have a larger internal diameter than the pipes that are attached to them; they are suitable only for vent-pipe, and should never under any conditions be used for

drainage work. Drainage fittings are constructed with interior shoulders *a*, Fig. 20. The pipe *b* screws up to the shoulder,

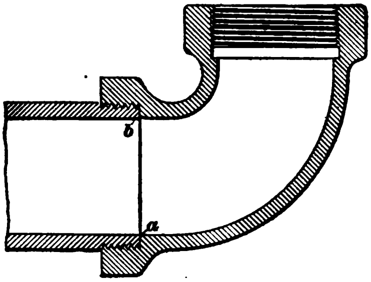


FIG. 20

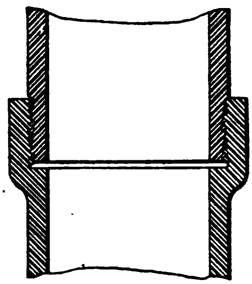


FIG. 21

making a smooth passage for the free flow of sewage.

Drainage fittings must be free from pockets when connected up; for this reason their internal diameter is made the same as that of the pipes to which they are attached; and in order that there may be very little space between the end of the pipe and the shoulder at the inner end of the socket, the dies must be so regulated that each thread will be cut to just such a length that when the pipe is screwed up tight the end will almost, but not quite, butt against the shoulder of the fitting, as shown in Fig. 21. These fittings can be had in all sizes and are made either of cast iron or malleable iron.

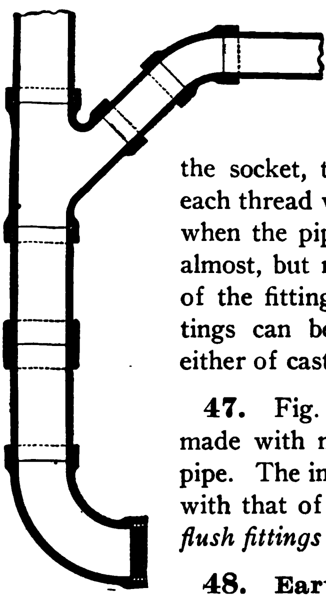


FIG. 22

**47.** Fig. 22 illustrates how connections are made with malleable-iron fittings and wrought pipe. The interior surface of the fittings is flush with that of the pipe; from this fact the name *flush fittings* is derived.

**48. Earthenware pipe fittings** are made chiefly in the form of bends, branches, and traps, and are similar in appearance to cast-iron drainage fittings. As many of the fittings are defective, they must be selected carefully, to obtain a good earthenware pipe drain.

### SPECIAL FITTINGS

**49. Cross-Over Fittings.**—Fig. 23 shows cross-over fittings *a* screwed in place. They are commonly used where

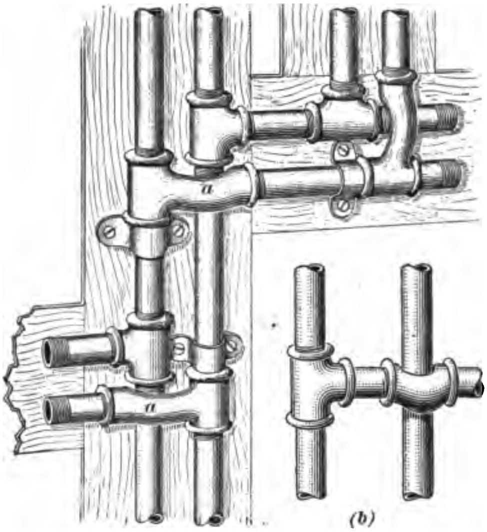


FIG. 23

two water pipes that are quite close together have branches that must cross the main lines. They are simply elongated **T**'s, so constructed that the branch arm of each will snugly and neatly straddle, or cross over, the adjoining pipe, as shown.

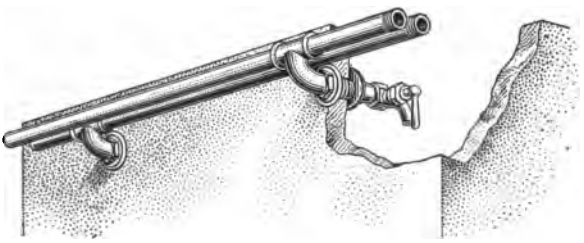


FIG. 24

One of these fittings accomplishes the same object as five ordinary fittings, thus saving considerable labor and material.

Where the distance between the two pipes is so far that a cross-over **T** cannot be used, an ordinary cross-over as shown in Fig. 23 (*b*) answers the same purpose.

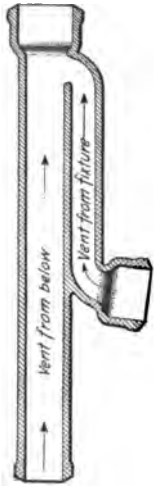



FIG. 25

**50. Laundry-Tub Supply Connection.** The hot- and cold-supply pipes at the back of a set of laundry tubs sometimes form traps between the faucets, and thus become liable to freeze and burst when the pipes are supposed to have been drained empty and the water has been shut off. To avoid this trouble, the special fitting shown in Fig. 24 has become quite popular. The faucets inside the tubs of course must be in line, which prevents the two pipes from being run level with and immediately back of the faucets. With this special fitting, however, the pipes are located above the line of the faucets and are run straight, so that they may be drained empty when the water is shut off. This fitting is particularly valuable in country homes that are unoccupied during the winter, for it prevents frost bursts at the back of the wash tubs.

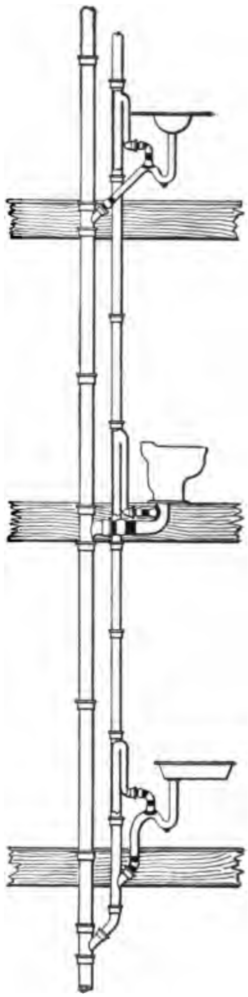


FIG. 26

**51. Back-Vent Fitting.**—A special fitting for back-venting plumbing fixtures is shown in Fig. 25. It is really a part of the vent stack and a back-vent branch combined in one casting. The vent branch is dropped down and a socket is cast on its lower end, for connecting to the back-vent pipe of the fixture. The

object of this fitting is to avoid a multiplicity of calked joints, and at the same time to prevent waste water from backing up and flowing into the vent stack, if the waste pipe should become choked. These fittings are especially adapted for use on vent stacks in recesses and other places where there is but little space; they form a neat, compact, and durable method of connection. When soil pipe is used for venting, a great saving in cost of installation can be made by using some of the many forms of vent fittings that can be obtained of the manufacturers and dealers. Fig. 26 shows the back-vent pipes for the traps of several fixtures connected to a vent stack by means of special vent fittings. These fittings are made in different shapes and sizes and with single- or double-drop branches.

## COCKS, VALVES, AND SUNDRIES

### COCKS

**52. Plug Cocks.**—In Fig. 27, the construction of an ordinary plug cock, also called a *ground-key cock,* is shown. The plug *a,* view (*a*), is turned truly circular, and is also tapered to fit the conical socket *b,* which is bored or reamed in the body of the cock. Formerly the plug and socket were

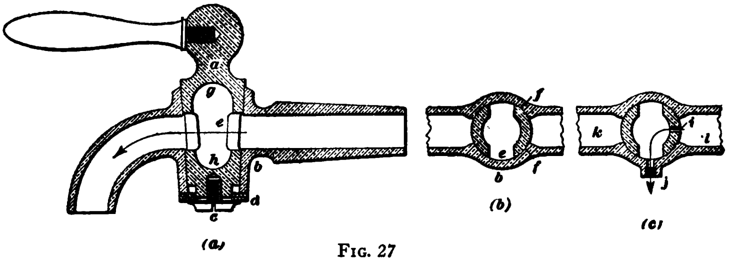


FIG. 27

fitted to each other by grinding with emery, and they thus became known as ground-key cocks. The plug is held in place by means of a screw *c* and the washer *d.* The washer fits over a squared shoulder on the small end of the plug, so that they turn together, as otherwise the screw would loosen itself every

time the plug was turned. The waterway through the plug consists of a rectangular slot *e*; the corresponding openings in the side of the socket should also be rectangular and of the same width. The tightness of the cock will depend on the perfection of the fit of the plug and the socket at the points *f*, view (*b*). If these surfaces are narrow, the cock will soon wear and become leaky.

**53.** As the plug is larger in diameter at the top edge of the slot than at its lower edge, there is a difference of area between the top and bottom of the slot; consequently, the pressure of the water within the pipes tends to drive the plug out of the socket. Thus, if the area of the bottom surface of the slot were 1 square inch and that of the top surface of the same were 1⅛ square inches, the difference in area would be ⅛ square inch. If the water pressure is 100 pounds a square inch, there is then a pressure of 100 pounds upon the bottom of the slot tending to hold the plug in place, and a pressure of 112½ pounds upon the upper end of the slot, tending to drive the plug out of the socket. Thus, there would be an unbalanced pressure of 12½ pounds tending to lift the plug, which must be resisted by the screw *c*. This is a matter of small account in common sizes, but in large cocks it becomes an important consideration.

Some manufacturers core out the body of the plug, as shown at *g* and *h*, to economize metal. As cocks having these cavities greatly obstruct the flow of water, their use should be avoided wherever possible. The best kind of plug cock is that in which the waterway through the plug is round, thereby avoiding unnecessary resistance to the flow of water. Plug cocks are either constructed with a handle, as shown in Fig. 27, or the top of the plug is shaped to receive a wrench.

**54. Stop-and-waste cocks** are a kind of plug cock having a small hole *i*, Fig. 27 (*c*), drilled through the side of the plug and another through the side of the socket at *j*.

The plug of the ordinary ground cock can be given a complete turn; but the plug of the waste cock can only be given a quarter turn, the rotation being limited by a pin attached to

and projecting from the plug, and moving in a groove cut in the top of the socket. The groove only occupies the space of one-fourth of the circumference, and as the plug cannot travel farther than the pin, the cock must be open when the handle is in one position and closed when in the other.

Care must be taken when placing stop-and-waste cocks upon a system that the draining hole *i* is on the proper side. For instance, when placing a stop-and-waste cock on a branch from a street main for the purpose of shutting off water from a building, the cock must be so attached that when shut the opening *i* will be toward the building, so that the pipes therein may be drained at that point. The end *k* of the stop-and-waste cock would be connected to the main, and *l* to the house pipes.

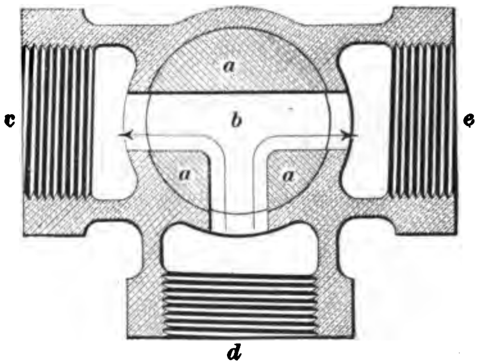


FIG. 28

**55. Three-way cocks** are constructed as shown in Fig. 28. The key, or plug, *a* has a three-way channel *b* passing through it, which can be made to communicate with the openings *c*, *d*, and *e* for the pipe connections. By turning the key *a*, communication can be made between *c* and *d*, while *e* is shut off; between *d* and *e* while *c* is shut off; between *c* and *e* while *d* is shut off; or they may all be open to one another, as shown in the illustration.

**56. Swing cocks,** one of which is shown in Fig. 29, are a special type of plug cock. The plug *a* is stationary and receives the water through the lower end. The socket *b* is provided with a suitable nozzle or discharge *c*, and can be turned on the plug. The waterway is opened or closed by swinging the nozzle. The form of swing cock shown is called a *basin swing cock*. It is attached to the basin top in such a

manner that when the nozzle *c* points toward the center of the basin, the cock will be open, and when tangential to the circumference of the basin the cock will be closed.

**57. Types of Plug Cocks.**—Fig. 30 (*a*) shows a *common, lever-handle, ground-key, plain, sink bibb* for lead pipe. It has a plain tail *a*, which is intended to be soldered to a lead supply pipe, and is called a plain bibb because the nose *b* is plain. View (*b*) shows a *ground-key, lever-handle,*

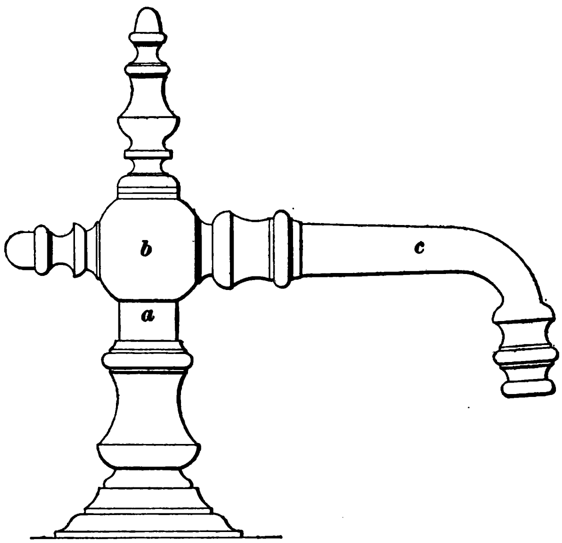



FIG. 29

*sink, hose bibb* for iron pipe. The nose is threaded to fit a common ¾-inch garden-hose coupling, and the tail is threaded to screw into an iron-pipe fitting. In view (*c*) is shown a *plain, lever-handle stop-cock* for lead pipe. A stop-cock is always closed when the handle points across the pipe. View (*d*) shows a *plain, ground-key wash-tray* or *tub bibb* for lead pipe. It is closed when the handle points downwards. View (*e*) shows a *lever-handle stop-and-waste cock* for lead pipe. View (*f*) shows a T-*handle stop-cock* for lead pipe; this form is also made with a waste same as in (*e*).

In Fig. 31 are shown additional forms of cocks for lead and iron pipes. View (*a*) shows a *plug cock* for iron pipes; this form is used on both gas and water pipes. View (*b*) shows a *lever-handle stop-cock* for iron pipes. View (*c*) shows a *lever-handle stop-cock* threaded for iron pipe and having a waste tube *a*. View (*d*) shows a *three-way ground cock* for

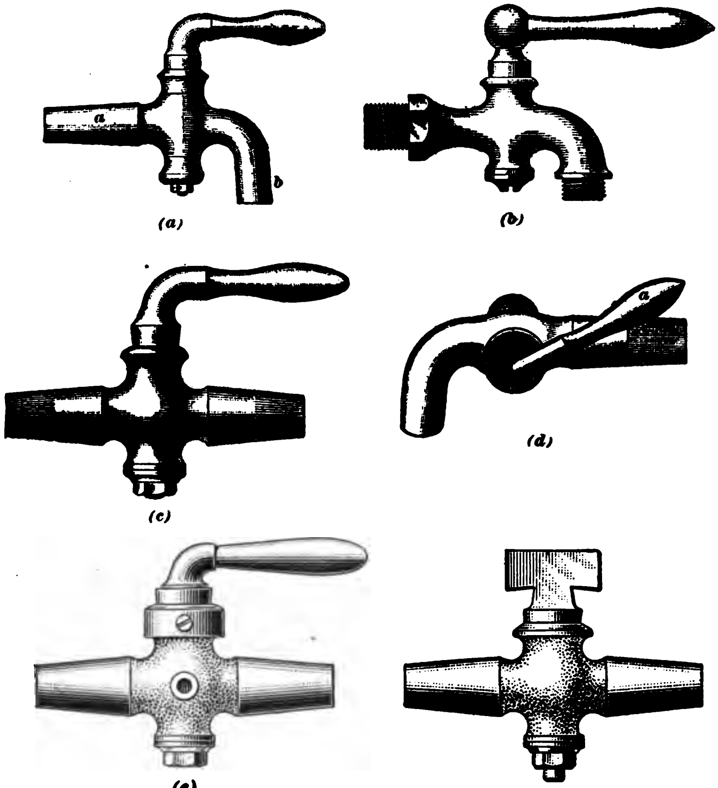



FIG. 30

lead pipe. The barrel is large, which indicates that the waterways in the plug are round. This cock is often used on the suction pipe of a pump that raises water from both a well and a cistern. The pump is connected to *a*, while *b* and *c* connect to the well and cistern, respectively. View (*e*) shows a *heavy-body, round way,* T-*handle stop-and-waste cock* for iron

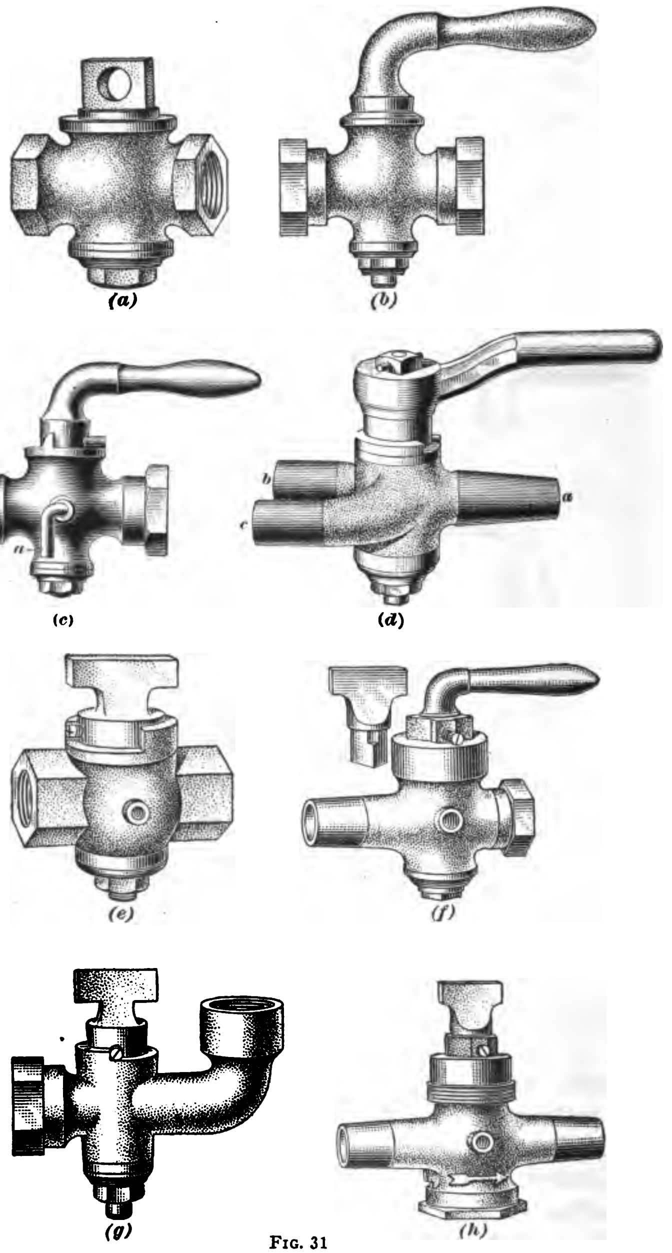



Fig. 31

pipe. View (*f*) shows a *combination lead and iron, lever-handle stop-and-waste cock,* which may also have a **T** handle as indicated. View (*g*) shows a **T**-*handle hydrant cock* for iron pipe. View (*h*) shows a **T**-*handle, curb, stop-and-waste cock* for iron pipe.

Plug cocks are adapted only for situations where it is not necessary to turn them frequently, as frequent use is likely to cause them to leak. When the stop-cocks are buried in the ground and must be operated by a rod, a *socket head* is attached to the plug instead of a lever handle. The rod is slipped into the socket and secured there by a setscrew; or, a crosshead may be cast on the plug, a rod and socket being used to turn the key.

**58.** Fig. 32 shows a *corporation cock* and ring coupling. The end *a* is threaded to screw into an ordinary cast-iron street

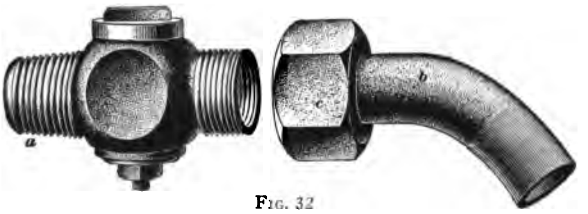



FIG. 32

water main. The barrel around the key is made extra heavy and is flattened on each side to fit the jaws of a certain make of tapping machine. After the coupling *b* is wiped to the lead connection or service pipe that supplies water to the building, the coupling ring *c* is screwed onto the cock, a ground joint being generally used to make the coupling water-tight. If a washer is used to make the connection tight, it should be made of a good grade of composition, leather, or sheet lead, but rubber should not be used. Corporation cocks are also made for iron pipes.

**59. Regrinding Leaky Plug Cocks.**—When a ground plug cock begins to leak, it is usually cheaper to replace it with a new one. If this cannot be done, it is customary to *grind* it; that is, to grind down irregularities existing between

the external surface of the plug and the internal surface of its socket, so that these surfaces will be in equal contact throughout their area and prevent water from passing between them.

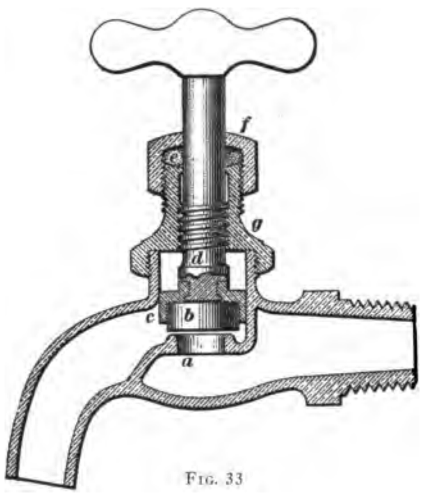


Fig. 33

The grinding process may be done as follows: The plug of the cock is removed and examined for the part that misses contact with the socket; this part will be dark in color and the bearing parts bright and polished. Fine emery or powdered bath brick is then sprinkled on the polished parts; the plug is inserted in its socket, turned by hand alternately to the right and left, and pulled out slightly and pushed in at the points where the motion is reversed. The turning motion will grind down the prominent parts of the plug and socket and the pulling-out and pushing-in motion, although slight, will cause a uniform film of grinding material between the surfaces. The plug should be occasionally dipped in water and resprinkled with emery.

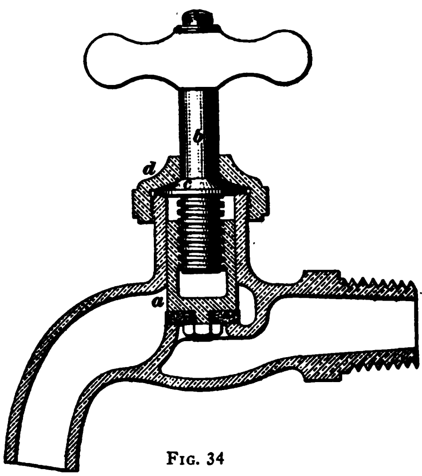


Fig. 34

**60. Compression Cocks.**—Compression cocks, also called *bibbs,* are much superior to plug cocks for general use. A common construction is shown in Fig. 33. The water passes through

the orifice *a,* which is closed by means of the valve disk *b.* The disk is made of some elastic material and is held in a block *c,* which is attached by a swivel point to the end of the screwed stem *d.*

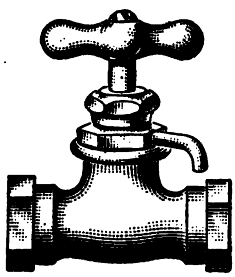


FIG. 35

If the block *c* is allowed to turn with the screw, the disk *b* will soon be injured and become leaky. The water is prevented from flowing out around the top of the stem *d* by a special washer that is compressed when the faucet is open or by placing lampwick or other suitable packing in *e,* which is pressed against the stem by screwing down the nut *f* on the bonnet *g.*

**61.** Compression cocks are also constructed in other ways, one of which is shown in Fig. 34. The block *a* is prolonged upwards and constitutes a nut that receives the screw thread of the stem *b.* The stem is provided with a solid collar *c,* which bears against the cap *d,* the joint being ground. Thus, the spindle does not rise as the valve opens.

The block *a* is made either square or round. When round, it has two lugs placed diametrically opposite each other, which, as the stem is turned, slide up or down in grooves in the casting of the cock, thereby preventing the block *a* from turning.

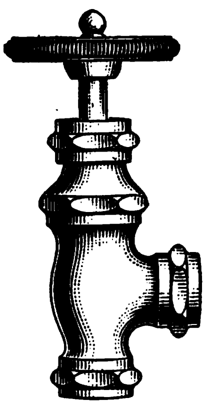


FIG. 36

Fig. 35 shows a **T**-*handle compression stop-cock* with waste and stuffingbox. Fig. 36 shows a *wheel-handle, angle, compression stop-cock.* All compression stop-cocks, bibbs, faucets, etc., work on practically the same principle, and can be procured in almost any design, with or without stuffingbox and with **T** or wheel handles.

**62.** A *rapid-closing compression cock,* known to plumbers as the *Fuller cock,* is shown in Fig. 37. The lower end of the stem *a* is offset and forms a crank *b* of sufficient radius to move the valve *c* to and from its seat. One half turn of the handle

will open the valve to its full extent, and the other half turn will close it. The handle may be turned in either direction.

In this form of cock the water pressure is on the back of the soft conical rubber valve *c*, and pushes the valve against

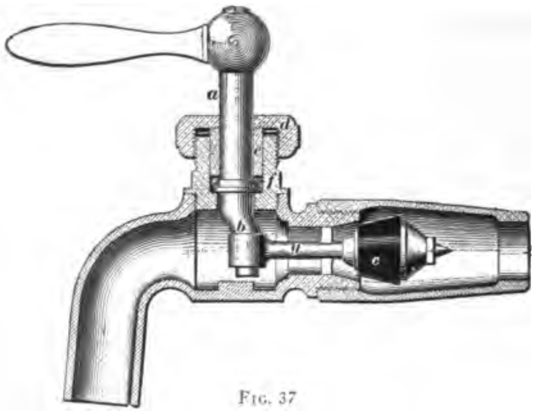


FIG. 37

its seat. The stem is made water-tight by screwing down the nut or cap *d*, which forces down the bushing *e*, and thereby compresses the packing at *f* around the stem. The valve is

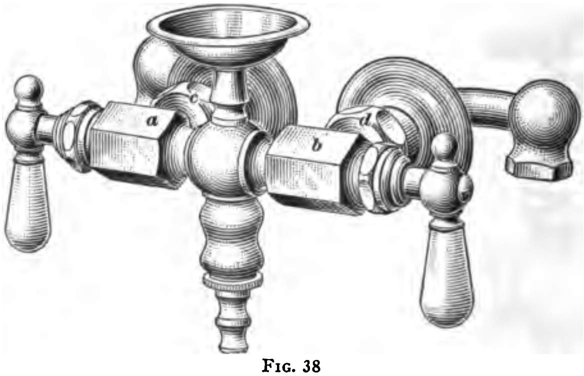


FIG. 38

guided to its seat by prongs cast on the stem *g*, to which the valve *c* is fastened. The Fuller bath cocks shown in Fig. 38 are constructed on the same principle. These cocks are used chiefly on low-pressure work where the water is free from grit.

**63.** Fig. 39 ($a$) shows a compression hose bibb, with an extension flange, the length of which can be adjusted as

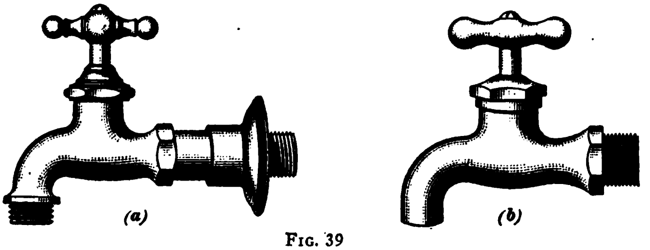


FIG. 39

required. View ($b$) shows a common compression bibb threaded for iron pipe. These bibbs may be obtained either plain or threaded for hose.

Fig. 40 ($a$) shows a *stub cock,* such as is used in wash tubs; it is called *stub* because it is short and takes up little room in the tub. In ($b$) is shown another form of cock for the same purpose as that shown in ($a$) and it takes up about 1 inch more room. The thimble $a$ is intended to be soldered to a lead pipe. These cocks may be obtained either plain or threaded for hose. At least 1 foot of hose should go with each set of tubs. This allows sufficient length for connecting to the water motor of a washing machine.

**64.** Fig. 41 ($a$) shows a common *compression basin cock* with locknut attachment to fasten it to a marble basin slab and having a coupling $a$ for lead pipe; this type has been commonly used on ordinary wash basins. The valve seat is located

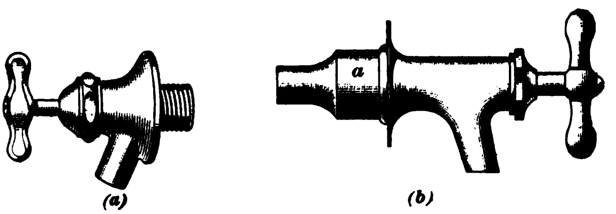
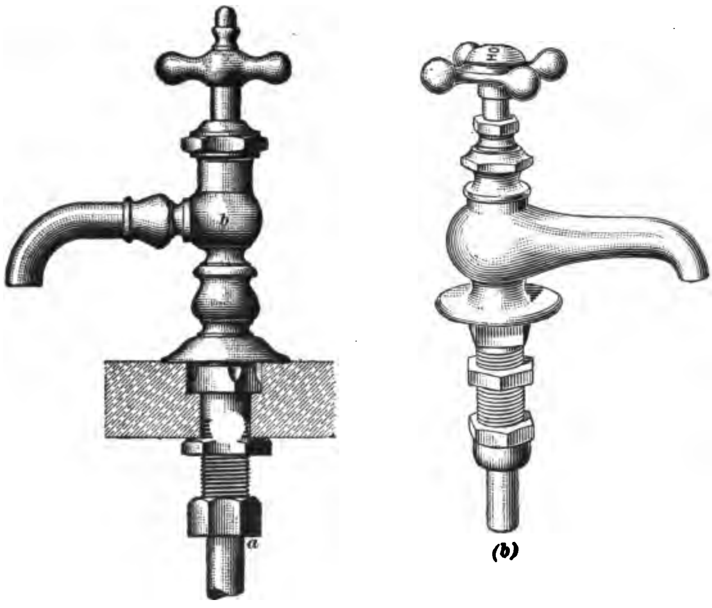


FIG. 40

at $b$. Very few of these are now used except for repairs or replacement. Fig. 41 ($b$) shows a *compression basin faucet*

having a four-ball handle, a stuffingbox, and a china index; this type of faucet, on account of its appearance, is rapidly taking the place of the style shown in view (*a*). Basin cocks of this kind can be procured in many patterns and with different styles of handles. When basin cocks are used on iron enamel basins, special washers are used underneath to take up the same thickness as would be taken by a marble slab.

**65.** Fig. 42 shows *Fuller basin cocks* intended to be set on the marble slab of a wash basin. The valve seats are




(*a*) (*b*)

FIG. 41

located at *a*. The valves should be closed when the handles are down, and the cocks should be attached to the slab in the manner shown in Fig. 41.

**66.** Fig. 43 (*a*) shows a *compression pantry sink cock* such as is commonly used on butler's-pantry sinks. It is simply a globe valve fitted with a long swan-neck discharge tube on top and a flange and locknut attachment below. In view (*b*) is

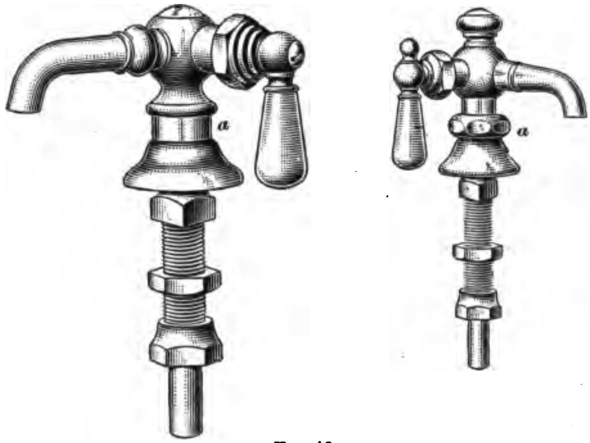
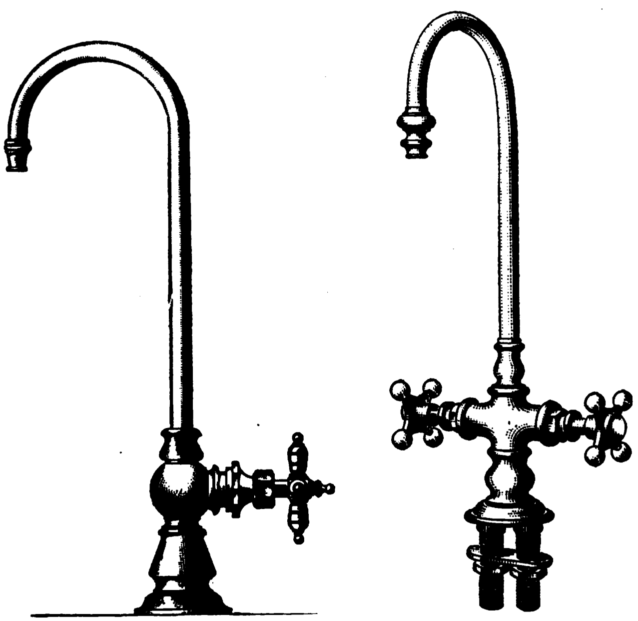



Fig. 42



(a) (b)

Fig. 43

shown a *combination compression pantry-sink cock.* These cocks can also be had with ground keys.

**67.** In Fig. 44 are shown two types of *compression bath cocks.* The valve seats are located at *a* and *b*; both valves discharge into the outlet *c*. These cocks are provided with locknut attachments on both hot and cold connections to secure them firmly in place at the foot of the bath tub.

**68. Self-closing compression cocks** differ from the common kind by having a stout coiled spring or some other contrivance under the cap to close the valve, instead of the usual screw and handle. The handle is always a lever of some kind, which is so arranged that the valve may be opened

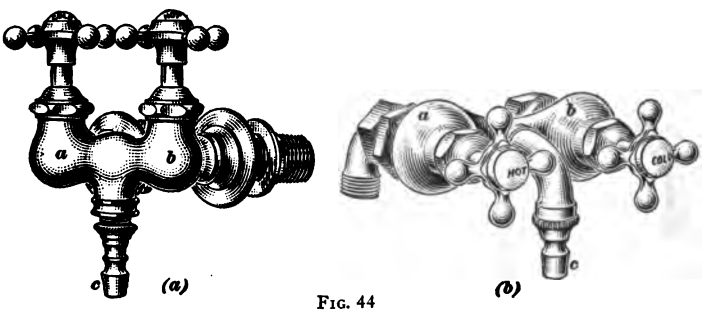



FIG. 44

by it, but as soon as it is released the spring or other contrivance automatically closes the valve.

The chief objection to the self-closing or spring cocks is that they close too suddenly and cause a shock upon the pipe system. The nature of the shock is similar to that received by a hydraulic ram when the large valve is suddenly closed. The best self-closing cocks, therefore, are those that close slowly. Self-closing cocks are used only where water is scarce, so that none may be wasted by careless persons leaving the cocks open. In buildings where the pressure is very high, air chambers should be used so as to prevent any trouble from water hammer.

In Fig. 45 (*a*) is shown a single-lever, plain, spring, sink bibb for iron pipe. The cock opens by pressing down on the lever

handle *a* and closes by the force of a spring when the lever is released. In view (*b*) is shown a rabbit-ear, spring sink bibb

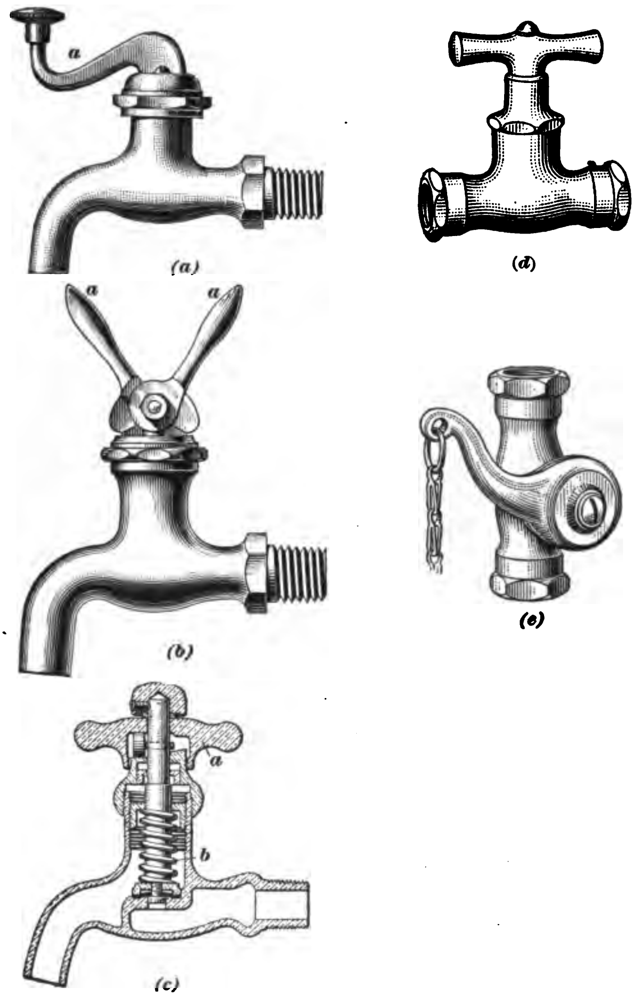


FIG. 45

for iron pipe. By squeezing the ears, or levers, *a* together the valve is opened against a strong spring, which instantly closes it when the ears are released. In view (*c*) a crosshead,

spring, plain, sink bibb for iron pipe is shown. By turning the crosshead *a* the valve is raised against a strong spring *b* which automatically closes the valve when the crosshead is released. In view (*d*) is shown a T-handle self-closing compression stop-cock. In view (*c*) is shown a ball-bearing lever-handle self-closing stop-cock for use on shower baths. There are many other patterns of self-closing bibbs and stop-cocks that can be procured, and they all work on practically the same principle.

**69. Ball Cocks.**—A form of ball cock chiefly used for regulating the flow of water into low tanks, such as are used for fixtures, is shown in Fig. 46 (*a*), in which the body of the valve is shown broken away so that the parts within may be seen.

The body *a* is bored to receive a cylindrical stem *b* to which the valve *c* is attached with a swivel joint. The water enters through the pipe *d* and escapes through the pipe *e*. The cock here shown is called an *elevated ball cock,* as by the extension of the pipe *d* the cock is placed close to the highest level to which the water is to be allowed to rise. Thus it is convenient of access for repairs.

The valve is operated by the buoyancy of a hollow ball, or float, which floats on the water in the tank. The float is attached to the end of a lever *g,* which is pivoted as shown and connected to the lever *h,* by which the stem *b* is raised or lowered. As the tank fills, the float rises, lifting the end of lever *g* and causing its other end to move downwards and carry with it the lever *h* and stem *b,* thus gradually closing the valve *c*. When the level of the water falls, the float falling with it moves the levers in the opposite direction and opens the valve so that water flows in.

As the discharge end of the pipe *e* is under water most of the time, unnecessary noise of the water in refilling the tank is prevented, and for this reason pipe *e* is called a ***hush pipe.***

**70.** In Fig. 46 (*b*) is shown another form of ball cock, which is used for the same purpose as the one just described. It is, however, placed in the bottom of the tank. In the

illustration, part of the body *a* is shown broken away so that the parts within may be seen. The body *a* is bored to receive the stem *b* to which is screwed the valve *c*. Water enters

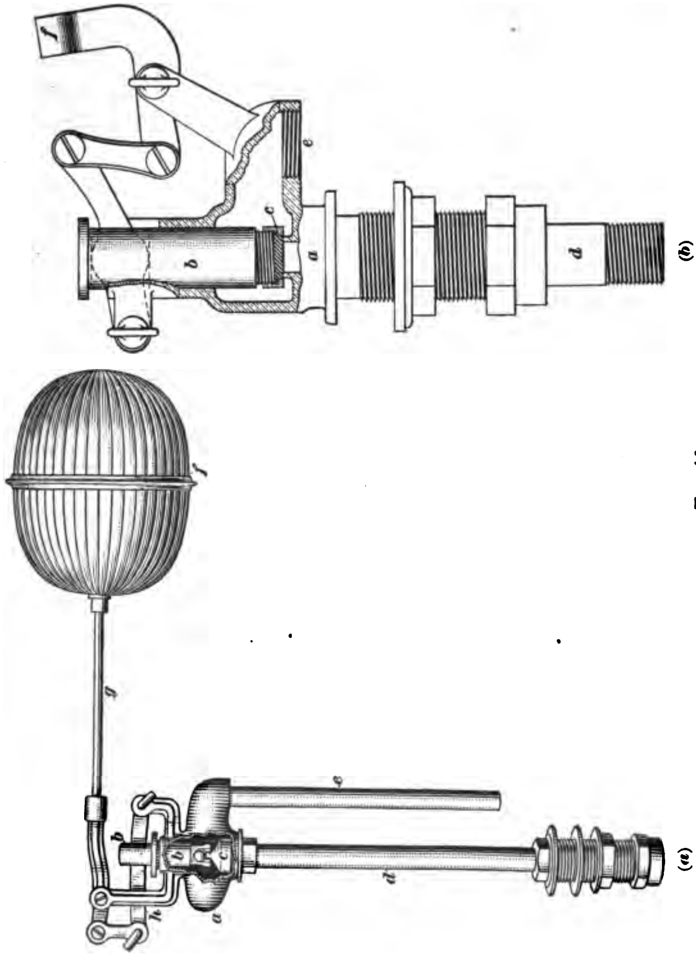


Fig. 46

through the pipe *d* and goes out through the opening *e*. The rod of a ball float, similar to that shown in Fig. 46 (*a*), is attached to the lever *f* and the cock is operated, through the levers shown, by the rising and falling of the float.

Since, for either of the cocks described, the full pressure of the water is on pipe *d,* it must be made of heavy material; generally a ⅜-inch extra-heavy cast or drawn brass pipe, properly tempered or annealed, is used.

On either form of cock for low tanks, a refill pipe is attached, through which a small stream of water is conducted to the overflow pipe of the flush-tank valve, and this stream continues to run until the tank fills with water and the valve shuts off the pressure.

The hollow ball or float, if made of copper, even though carefully made, is liable to leak and fill with water; it will then sink, the valve will fail to close, and the water will overflow the tank. Glass floats are very durable and are not so likely to leak.

## VALVES

**71. Globe Valves and Gate Valves.**—The ordinary *globe valve* shown in Fig. 47 and the *angle valve* shown in Fig. 48 belong to the compression class. The waterway through a globe valve is so contorted that the flow of water is obstructed to a serious degree.

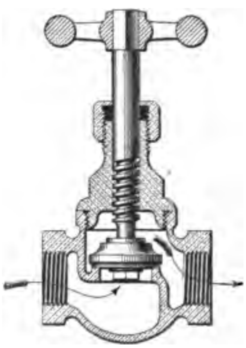


FIG. 47

Both globe and angle valves should be attached to the pipe system in such a manner that the valve will close against the pressure, as otherwise when the valve is on its seat the water will work up along the valve stem and leak. The ordinary globe valve is used on straight pipe, while the angle valve is used at the junction of two pipes at right angles and oftentimes saves using an elbow.

The gate valve shown in Fig. 49 serves the same purpose as the globe valve, but furnishes a freer passageway for the water. By turning the stem *a,* the wedge-shaped disks *b* and *c* are moved across the seats *d* and the orifice is opened or closed gradually. The disk *c* has cast on its lower side a projection *e,* which rests on a corresponding projection *f* cast to the valve body. These projections prevent the disk *c* from

moving down too far. The disks are wedged apart and pressed tightly against their seats by turning the stem *a* in the proper direction.

Where gate valves can be used on water-service and supply pipes they are preferable to the ordinary stop-cock or the globe

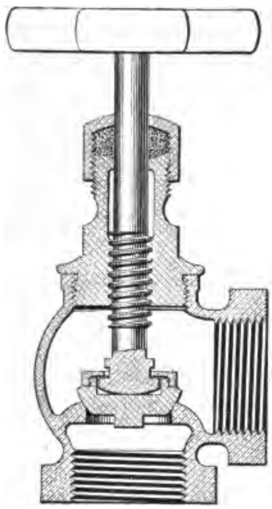


FIG. 48

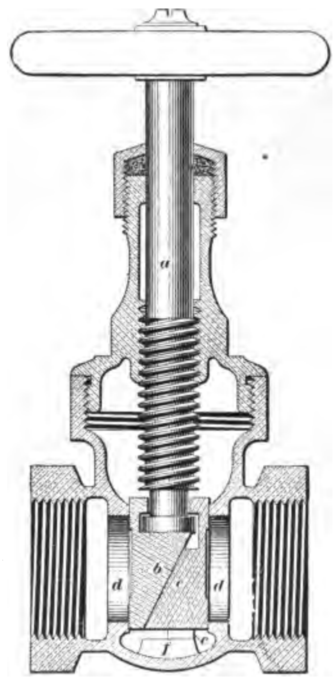


FIG. 49

valves because of the full waterway provided in the valve and because there is no chance of corrosion or stoppage.

Gate valves are made quick-acting by substituting a lever and sliding stem for the screw stem shown.

**72. Check-Valves.**—A form of valve that permits the flow of a fluid in one direction only and positively prevents a reversal of the flow is called a **check-valve.** There are two kinds of check-valves in common use.

The *globe check* is shown in Fig. 50. The valve *a* is a solid disk of metal having a beveled edge to suit the seat *b*, and is

guided by the wings *c* and *d*, as shown. The fluid passes in the direction of the arrows. A cap *e* gives access to the valve.

An improved form of check, known as a *swing check*, is shown in Fig. 51. The valve disk *a* is attached to an arm that swings on a pin, as shown. The passage of fluid through this valve is more direct than in the globe check, and the pressure required to open the valve is much less. The fluid passes through the valve as shown by the arrows, that is, from *b* toward *c*. In case of a rapid flow of water, the projection *d* on the end of the arm to which the valve is attached strikes against the bottom of the screw *e*, and is thus prevented from going too far.

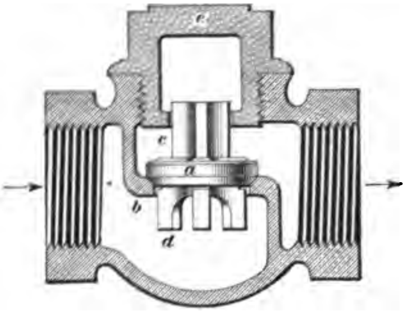


FIG. 50

These valves are used on steam or water systems, but are not adapted to service on sewage lines.

**73.** A check-valve especially adapted for drainage purposes, and called a *back-water valve*, is shown in Fig. 52. It is used to prevent water in the street sewers from backing up into the house drains, as is liable to occur during a heavy rainfall if the sewers are too small or have too little fall. If the house drains have too little fall toward the valve, it is liable to cause a chokage by allowing the liquids to pass and retaining the solids; hence, back-water valves should not be used on a system of house drainage, where it can possibly be avoided. This valve is not necessary on a sewer system where there are no openings in the sewer line below the first floor.

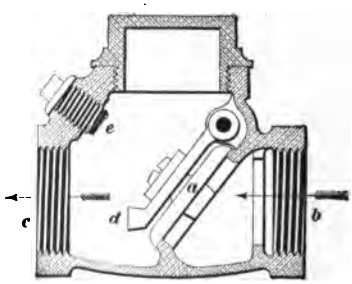



FIG. 51

When a back-water valve is necessary and there are any openings, such as sinks, closets, etc. in the basement, the valve should be placed so that rainwater leaders, if connected to the sewer, are connected on the main line between the main house trap and the back-water valve; otherwise, the pressure from the sewer side would possibly be greater than that from the house side and water would overflow from sinks, etc. into the cellar.

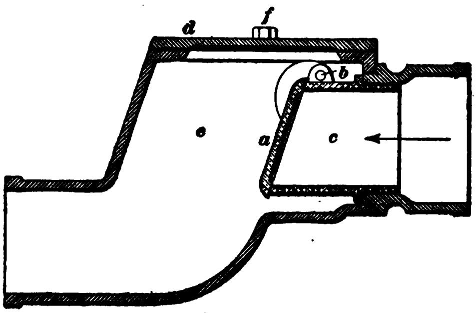


FIG. 52

The valve *a* swings on a pin *b*; the inlet is indicated by the arrow. The valve and its seat *c* should be made of brass, so as to avoid corrosion. For facilitating the cleaning out of the valve, a handhole and cover *d* are provided in the body *e*; the cover is held in place by bolts *f* on each side. To prevent leaking, packing should be placed under the cover.

**74.** The form of back-water valve shown in Fig. 53 is used chiefly to drain water from the basement floors, etc., where there is danger of water backing up from the sewers. The valve is composed of a hollow copper float *a*, encircled by a soft-rubber ring *b*. A rest, or stop, *c* for the float is attached to the brass valve seat *d* by four arms. These arms also act as guides to lead the valve to its seat when the sewage water rises in the drain pipe *e* and buoys up the valve. When the water falls in *e*, the float will fall from its seat and descend with the receding water until it reaches its stop, as shown,

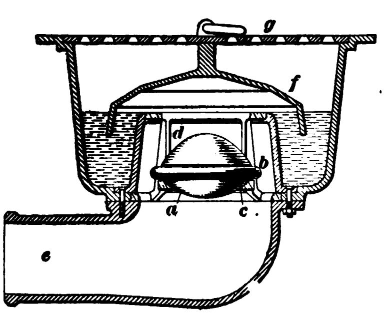


FIG. 53

when it will be again open for surface water. A bell-shaped casting *f* suspended from the perforated cover *g* dips into water and forms a seal to prevent drain air from entering the building. This form of check-valve is commonly called a **back-water trap.** Where there are no openings in the sewer line below the first floor, a trap of this character can be used to drain a cellar; back-water traps of different construction can be procured to answer the same purpose.

**75. Safety Valves.**—A certain kind of valve is designed to open when the pressure within the vessel to which it is

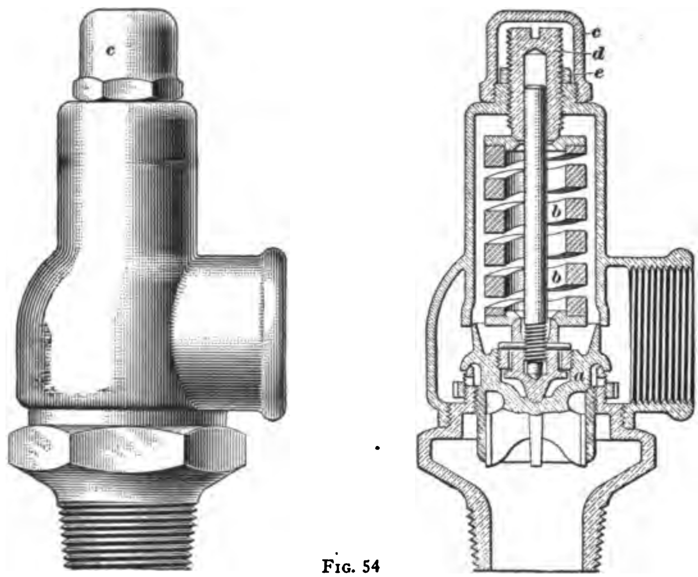



FIG. 54

attached becomes greater than that for which the valve is set; it then permits the fluid to escape until the excess of pressure is relieved, when it closes. Such a valve is known as a **safety valve.**

One form of safety valve in common use for plumbing work is the *spring safety valve* shown in Fig. 54, sometimes called a *water-relief* or *cylinder-relief valve*. The valve *a* is held down on its seat against the upward pressure of the water by a spring *b* bearing down on the valve. To adjust the valve, the

cap *c* is removed and the tension of the spring *b* is increased or diminished as desired, by adjusting the screw *d*, which bears down on top of the spring. A locknut *e* holds the adjusting screw firmly in position. The cap *c* protects this screw and gives a finished appearance to the valve. A check-valve should never be placed on a high-pressure hot-water heating line unless a relief valve of high grade and quality is used on the house side of the check.

A relief valve, when properly constructed and regulated, insures an automatic opening of the valve, thus preventing any excessive pressure in the system to which the valve is attached.

**76. Vacuum Valves.**—Vacuum valves are similar to safety valves, except that they operate in the reverse way, being closed by the internal pressure and opened by the external, or atmospheric, pressure. Thus, if a vacuum is being formed within a boiler, which is thereby in danger of collapse from the external pressure of the atmosphere, the valve will open and will allow enough air to enter to destroy the vacuum.

**77. Pressure-Reducing Valves.**—A device known as a pressure-reducing valve, or *water-pressure regulator*, is employed for reducing the pressure of gases or liquids; the form used by plumbers for reducing the pressure of water will be considered here. They are chiefly used to reduce the pressure within the building to a safe and suitable point in cities where the street water pressure is too great for the plumbing systems in the buildings to withstand safely. They are generally attached to the pipes from the street mains whose pressures are to be reduced, and are usually located in the cellars of the buildings. When the pressure exceeds 60 pounds to the square inch, the use of a pressure-reducing valve helps to prolong the life of ordinary water systems, water fronts, range boilers, etc.

**78.** One form of water-pressure regulator is shown in Fig. 55. The valve consists substantially of a brass body or shell similar to an ordinary stop-valve; a stem having a valve disk in the center, and a leather or rubber cup at each end, for sensitizing the action of the stem to the motion of the

water; a removable cap at the bottom for removing parts for repairs; a brass cap or cylinder encasing a spring, and a set-screw at the top for adjusting the tension of the spring.

When water is admitted to the regulator through the inlet pipe *a*, it flows to the pipe *d* on the outlet side, the pipe *d* fills with water, and a back pressure is formed that acts upon the upper cup *e*. As this cup is larger than the lower cup *b*, the valve is gradually closed by the back pressure exerted on *e*. When a faucet is opened on the outlet side of the valve, it

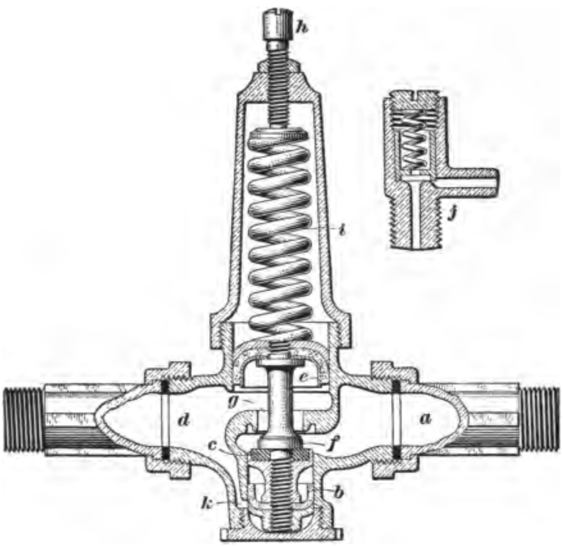



FIG. 55

reduces the pressure in *d*, and the pressure in *a*, acting on the cup *b* together with the force exerted by the spring, opens the valve. When the regulator closes, a primary valve *f* enters the port *g*, partly closing off the water before the valve *c* is seated, thus preventing water hammer. The small water passage *k* communicating with the discharge pipe *d* is a relief port to the space under the cup *b* which allows a free motion of the valve. The regulator can be adjusted at any desired pressure on the outlet side, through the tension of the spring *i*, by turning screw *h* to the right to increase, and to the left to reduce,

the pressure. If the regulator is used on a job where hot water is supplied, a relief valve similar to that shown at *j* should be used to provide for the expansion of the water. The valve may be attached to either the hot- or cold-water pipe; but as hot water is liable to decompose the leather washers, it is better to place the valve on the cold-water pipe near the sink or other convenient place for drainage.

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### SUNDRIES

**79.** Fig. 56 (*a*) shows a *bent boiler coupling* and *spud* screwed together by a coupling ring *a*. The end *b* of the spud is threaded iron-pipe size for screwing into the tapping of an ordinary kitchen boiler; the end *c* of the coupling connects to iron or brass pipe. In view (*b*) is shown a straight boiler connection, such as is generally used on the bottom of a boiler. These couplings permit of quick connection or disconnection of pipes to boilers or heating apparatus, and should have ground joints if possible.

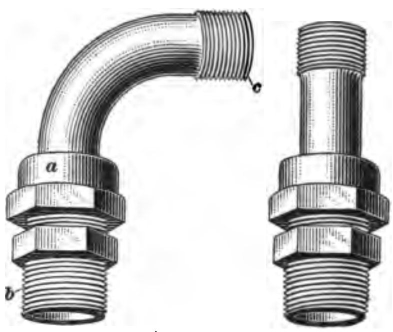

FIG. 56

**80.** Fig. 57 (*a*) shows a *chain stay* commonly used on wash-basin slabs. The basin plug is attached to a chain, which in turn is hooked to the ring of the chain stay. A nut *a* on the under side of the basin slab holds the chain stay tight. There are many other kinds of similar stays for the purpose of holding rings, soap cups, etc. View (*b*) shows a *cock-hole cover* commonly used to close a cock hole in a marble wash-basin slab or iron enameled basins, sinks, etc., where only one faucet is used. It is held tight by the nut underneath.

**81.** Fig. 58 (*a*) shows a *straight brass ferrule*. The part *a* is finished smooth to a distance of about 1 inch, while the

remainder is left rough. This ferrule is used to connect a lead pipe to a cast-iron pipe, the lead pipe being soldered or wiped to the end *a*, while the other end is calked into the pipe socket. View (*b*) shows a bent brass ferrule finished the same as that shown in (*a*). View (*c*) shows a bent brass ferrule recessed on top to receive lead pipe. The surface at *a* is finished for soldering purposes. View (*d*) shows a quarter-bend brass ferrule finished the same as those shown in (*a*) and (*b*). These types of bent ferrules are useful where space is limited. View (*e*) shows a straight 2-inch brass ferrule, and view (*f*) shows a reducing brass ferrule used to connect 1½-inch or 1¼-inch lead pipe to a 2-inch soil-pipe hub. To make a perfect connection, the brass ferrule should be slightly larger than the lead pipe entering it. For example, if a 2-inch lead pipe is used, a full 2-inch brass ferrule should be used. All brass ferrules have a bead on one end for calking into a cast-iron pipe socket.

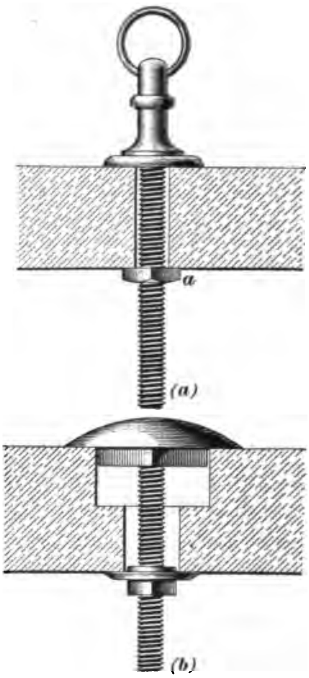

FIG. 57

**82.** Fig. 59 (*a*) shows a *male nipple*, and (*b*) a *female solder nipple*. The plain ends of these nipples are finished smooth for soldering to lead pipes. The other end of the male nipple is threaded to screw into an iron-pipe fitting, and the other end of the female nipple to screw over an iron pipe.

View (*c*) shows a common *plug* and *socket*. The plug *a* is shown set in the socket *b*. Brass plugs are ground to fit the sockets; rubber plugs, however, are commonly employed. The plug and socket shown are generally used in baths lined with sheet metal. A strainer is cast on the bottom of the socket.

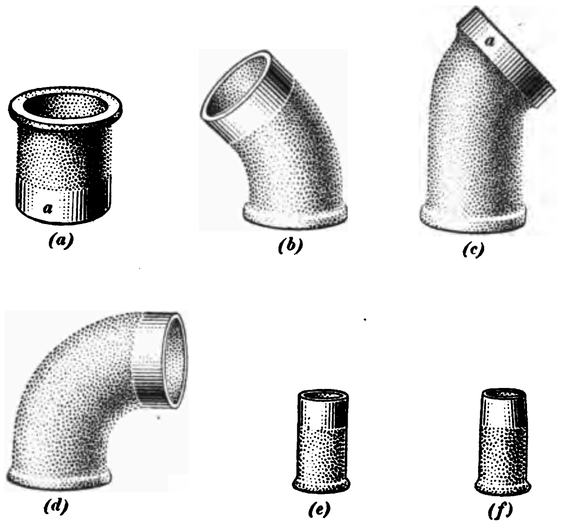


FIG. 58

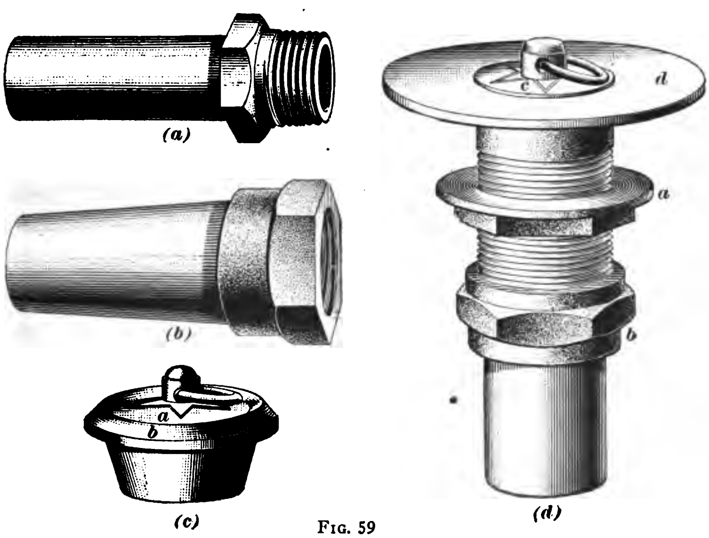


FIG. 59

View (*d*) shows a ***waste plug*** and ***socket coupling*** with lock-nut *a*, straight coupling *b*, and rubber plug *c*. The flange *d* sets in a countersunk part of the bath or sink to make a flush bottom. A strainer, generally cross-bars, is located inside the opening about ¼ or ½ inch below the plug.

# SOLDERING AND WIPING

## SOLDERING

### FOREWORD

#### CLASSIFICATION

**1.** The process of joining metals by means of melting other metals having a lower fusion point than the metals to be joined, and where the parts to be joined are heated principally by either a copper bit, a blowpipe flame, or some equivalent means, is called *soldering*. The process of soldering is divided into two classes. In soft soldering, which is frequently called soldering, for short, the solder is composed of lead and tin and is very soft. In hard soldering, which is best known by the name of *brazing*, the solder is quite hard, being an alloy of copper, zinc, tin, silver, etc.

**2.** The process of soft soldering is divided into *copper-bit work* and *blowpipe work*. In copper-bit work, a copper bit is used for melting the solder and heating the metals. The copper bit is in some localities miscalled the *soldering iron*. In blowpipe work, the solder is melted and the parts to be joined are heated by means of a blowpipe flame. In both copper-bit work and blowpipe work, there is a preliminary operation known as *tinning*, in which the metals to be united are properly prepared for the final operation of soldering.

GENERAL INSTRUCTIONS

**3.** Melted solder exhibits a strong tendency to adhere to the surface of the ordinary metals, and to unite solidly with them while cooling. However, the least film of oxide, grease, or dirt upon the surface of the metal will usually prevent the adhesion; therefore, the surface must be thoroughly cleaned, or it must be coated with some substance that will reduce the oxides to the metallic state, or that will destroy the grease and will deposit a thin film of zinc upon the surface to be soldered.

The kind of solder known as *half-and-half* is suitable for joining lead, copper, brass, zinc, and iron to metals of the same kind, or for joining any of them to any other named. Block tin, however, requires a more fusible solder. Care must be taken that the temperature of the bit is not high enough to melt the tin. Rosin is the proper flux for tin.

Copper, brass, or iron not galvanized may be prepared to receive solder by cleaning the surfaces and applying chloride of zinc. If it is necessary to solder galvanized pipe to lead or some other pipe, the galvanizing should be removed from the pipe by filing, before tinning. A stronger joint is insured by tinning the metal before soldering, in which case rosin is the proper flux.

Galvanized iron or sheet zinc should be cleaned with muriatic acid before the solder is applied. All metals, except lead and tin, should be tinned previous to wiping. Lead and tin only need to be shaved clean.

**4.** The temperature of the metals must be raised, at the point where the solder is applied, to the fusing point of the solder. When soldering metals having a temperature of fusion but slightly greater than that of the solder applied, such as lead or tin, care is necessary to avoid melting them and thus making a hole where it is not wanted.

Solder flows best at high temperatures, provided the temperature is not high enough to oxidize it. Solder will flow into a joint until it is chilled; therefore, it will flow farthest when it possesses a large excess of heat above that necessary to

maintain it in the fluid condition. Soldering should not be done with bits that are barely hot enough to melt the solder, because the solder will not flow into the joint properly.

**5.** The bits used for soldering must be of sufficient weight to retain, during a reasonable time, a temperature high enough to heat the metal and fuse the solder. If they are too light, the frequent reheating required by the bits will make considerable trouble and the soldering will be very uneven; if too heavy, the work of handling them will be too laborious. Care must be taken not to overheat or burn the bit. If this happens the bit will have to be retinned before it can be used again.

The metal to be soldered may be heated by mere contact with the hot bit, but the heating is done more effectively and much quicker by melting a little solder at the point of the bit. This body of solder increases the area of the contact and conducts heat from the bit to the metal with great rapidity.

When working with the blowpipe, the necessary heat is applied directly to the metal by the flame, which must be so handled as to avoid overheating or oxidizing either the metal or the solder.

## SOFT SOLDERING

### TINNING

**6. Operation and Object.**—The operation of tinning consists in spreading a thin layer of solder, or sometimes of pure tin, upon the surfaces of other metals and causing it to adhere and make a firm metallic union therewith. The object of the tinning is so to prepare the surfaces of the metals that they will readily unite with the melted solder that is applied to them in the process of soldering joints. All the common metals become tarnished when exposed to the atmosphere, and the tarnished surface must be removed, to expose the bare, clean metal to the influence of the solder; otherwise, the solder will not, under ordinary circumstances, adhere to the metal.

In tinning metals, great care should be taken to have the

tinning of a uniform thickness and free from imperfections. Small lumps or ridges of solder in the tinning coat will interfere with the proper closing of joints and seams, and care must always be taken to remove these lumps. Any superfluous solder can be shaken off or wiped off with clean waste or a clean cloth.

**7. Tinning a Copper Bit.**—Copper bits must be tinned before they can be used for soldering purposes. To do this, the bit must be heated until it melts solder, but not until it is red hot. It is then laid on a brick or other suitable material and one of the flat sides is filed at the point to a distance of about 1 inch. The filed surface, after thorough cleaning, is rubbed on a brick, over which pulverized rosin has been sprinkled. The hot copper will quickly melt the rosin, the fumes of which prevent the copper from tarnishing. Melt some solder on the brick and rub the bit into the rosin and solder. The rosin facilitates the adhesion of the solder to the cleaned copper. One of the sides adjoining that already tinned, as shown in Fig. 1, is now cleaned and tinned, and the bit is ready for use. If the bit is red hot, it will oxidize the instant that the file leaves it, and no tinning can be done with rosin for a flux. Rosin is the best flux for tinning bits for plumbers' use.

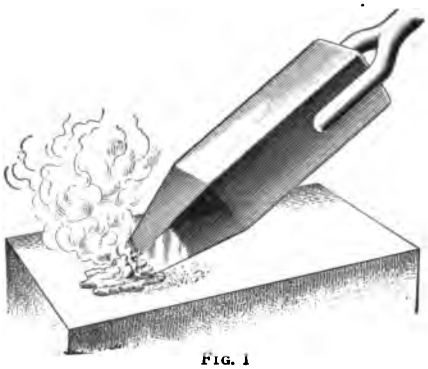

FIG. 1

**8.** A quick and convenient way of tinning a bit that is to be used for soldering metals other than lead, is to rub it, while hot, upon a block of sal ammoniac having a few drops of solder spattered over its surface. The sal ammoniac reduces the oxide, and the clean copper seizes the solder instantly on coming in contact with it. A bit may often be retinned in this manner without having to be filed.

Another quick way, which is particularly adapted for bench work and which is quite popular with cornice makers and tinsmiths, is to dip the point of the bit, while hot, in a saturated solution of sal ammoniac and water, before rubbing it on the solder. This method, however, tins all four sides, which is not always desirable. Neither of these methods must be used for tinning solder nipples, ferrules, or anything to be used for wiping.

When a bit is overheated, the coating of solder, or the *tinning,* as it is called, is reduced to a yellow powder and is destroyed. When this happens, allow the bit to cool off enough to file and retin. It cannot be used to solder with until this has been done. No copper bit that has been used in soldering anything

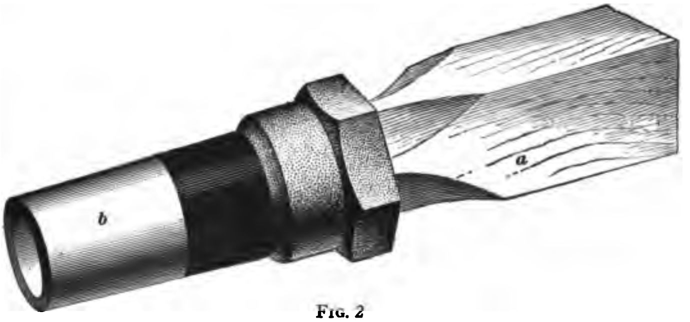


FIG. 2

with acid of any kind, or has been tinned with sal ammoniac, should be used for tinning nipples for wiping until it has been retinned, using rosin for a flux.

**9. Tinning Solder Nipples.**—Solder nipples are made of brass and must be tinned before they can be properly soldered to lead pipes. In order to hold the nipple during tinning, a block of wood *a* is whittled down at one end, and driven into the threaded end of the nipple, as shown in Fig. 2. The plain part of the solder nipple, including the end, is then filed perfectly clean. The end is a very important part of the tinning, as the solder must fuse with the end of the solder nipple if tinned properly. This very materially strengthens the joint, all the outer surface being filed off to a suitable distance, which for wiping purposes is usually from 1 inch to 1¼ inches.

The cleaning *b* is now ready to be tinned. Sprinkle some powdered rosin on the cleaning, and melt some solder off the strap or bar with the bit. The tinned part of the bit is next

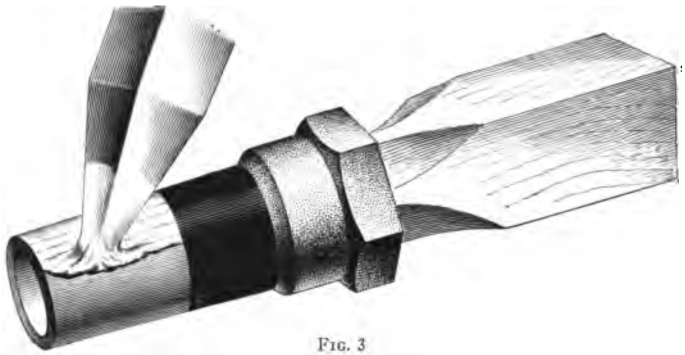

FIG. 3

laid over the drop of solder, which melts and adheres to the cleaning, as shown in Fig. 3. By working the bit over the cleaned surface, the solder is made to adhere to the entire cleaning. If it does not adhere freely, a sprinkling of rosin will help it to flow. Care must be taken to leave no part of the cleaning untinned. If the tinning is done properly, the cleaning will be covered with a thin, uniform, and bright coating of solder. The nipple is now ready to be soldered to a pipe.

**10. Tinning Spuds.**—Spuds are tinned similar to nipples, the only difference being that the tinning ends at the edge *a*, Fig. 4, instead of on the small shank *b*. This method


FIG. 4


FIG. 5

enables the plumber to wipe the joint easily and prevents the joint from being weak by a lack of solder at the place where it should have greatest strength.

**11. Tinning Brass Ferrules.**—Brass ferrules are filed and tinned the same as solder nipples, except that the edge *a,* Fig. 5, and inner surface *b,* which extends inside the ferrule about ¼ inch, are tinned as well as the outside cleaning *c.* As all cast-brass ferrules are liable to have blowholes, it is advisable to examine for and solder them while tinning the ferrules

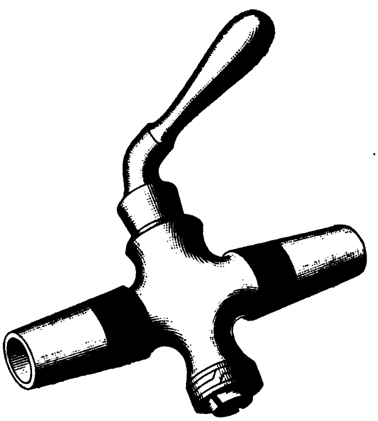

Fig. 6

**12. Tinning Ground Key Cocks.**—Ground key cocks are tinned with the keys left in. If the key is removed before tinning, the body is liable to become warped by the heat to which it is subjected during the operation, and will remain warped when cooled. The ground fit between the key and the body will thus be destroyed, and consequently the cock will leak in service. The parts that are not to be tinned are painted with black soil, as shown in Fig. 6.

**13. Tinning Compression Cocks.**—Compression cocks usually have rubber washers and packings. To prevent injury by the heat, the bonnet, the valve stem, etc., should be removed during tinning, when the cock will appear as shown in Fig. 7.

**14. Tinning a Bent Coupling.**—Bent couplings are rather awkward to tin. The quickest way is to have a piece of pipe to fit the coupling. If this is not handy, the stick *a,* Fig. 8, must be cut to fit snugly, because it cannot be driven in far. The coupling ring *b* must be tied up to the stick, or otherwise secured to prevent its slipping down or working toward the cleaning while the joint is being wiped. A good plan for securing the

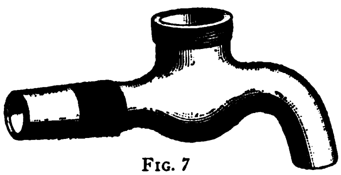

Fig. 7

ring is to pack thin paper in between the ring and the stick, as shown at *c*.

**15. Tinning Sheet Copper.**—The edges of sheet copper must usually be tinned before they are bent up for lock seams. This work is best done by laying the sheet on an inclined plane surface and tinning the edges by working from the top down, as shown in Fig. 9. If the sheets are new and moderately clean, the edges will not require scraping and can then be tinned with chloride of zinc as a flux; if they are tarnished, they must be scraped clean before the flux is applied.

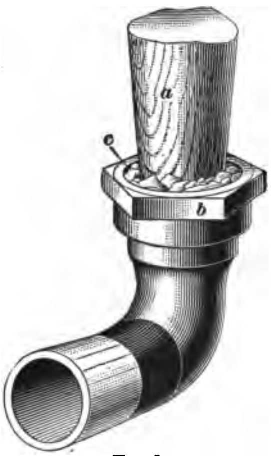

FIG. 8

**16. Dip Tinning.**—Many articles can be tinned all over, after they have been cleaned and coated with a flux, by dipping them in melted solder. This process is known as *dip tinning*. It is bad practice to dip brass in a pot of molten solder that is to be used for wiping purposes, because some of the zinc, of which the brass is partly composed, will melt out and alloy with and spoil the solder.

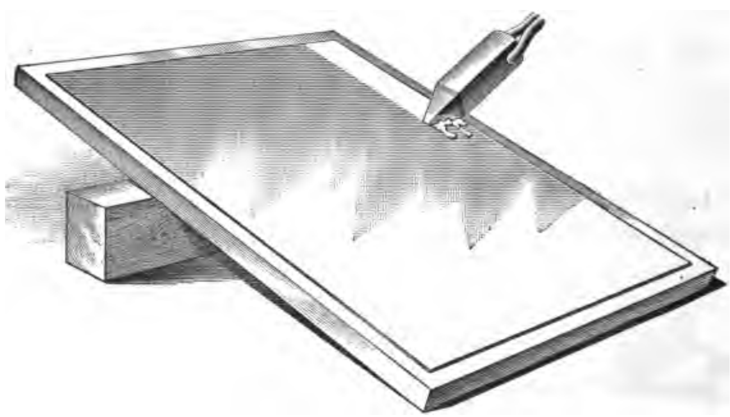

FIG. 9

Articles composed wholly of copper may be dipped in the solder pot without injury to the solder, provided they are perfectly clean and free from filings, etc. The very best way is to use the wiping solder for wiping purposes only and to tin all nipples, etc., with the copper bit.

Iron articles may be tinned by thoroughly cleaning the surfaces and treating them with chloride of zinc or sal ammoniac before the solder is applied. Care must be taken not to try to wipe joints on any pipe or nipple that has been tinned in this manner, as the flux used will prevent the proper fusion of the solder and result in lost labor and patience.

**17. Soiling.**—The object of soiling is to prevent the solder from flowing upon, or adhering to, the surfaces that are protected by it. The workman is thus enabled to keep the solder within the proper limits and to produce clean, nice-looking work, free from all unsightly splashes or irregularities. For work that is to be done with the bit or with the blowpipe, a width of soiling from $\frac{1}{2}$ to 1 inch is usually enough.

The solder should not be applied until the soiling is dry. In fair weather it will dry quickly; but too slow drying may be hastened by applying a moderate heat. Strong heat will spoil it.

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### SOFT SOLDERING SEAMS AND JOINTS

**18.** The soldering done with the copper bit is principally on flat and locked seams; on bead, or floated, seams; on cup joints; and on overcast joints.

The flat seam, which is also called lap seam, is used only for joining thin sheets of tin, otherwise tinned sheet iron, copper, or zinc. In this seam one plate simply laps over the other and the two are thus soldered together. It is not suitable for work requiring a strong seam. The lock seam is made by doubling over an edge of each sheet and hooking the sheets together. In the bead seam, which can only be used for comparatively thick pieces of metal, the edges to be joined are beveled and butted together, thus leaving a **V**-shaped space that is filled with solder applied drop by drop. The solder is

afterwards given a smooth finish by melting it with the bit and drawing the latter slowly along the seam, thus causing the solder to flow. The term *flow* has been corrupted to *float* by mechanics, and this corruption has caused the seam to be known as a *floated seam*. The cup joint and the overcast joint are used in joining pipes and similar objects by soldering.

**19. Soldering a Lock Seam.**—A completed lock seam is shown in section in Fig. 10 (*a*). When starting to make the seam, all surfaces that come in contact in the inside of the seam must be thoroughly cleaned before the folding is done. When the metal is tinned upon one side, as in the case of tinned

(*a*)

(*b*)

Fig. 10

copper, the folds are turned so that the tinned surfaces will face each other. If the copper is without tinning, it is advisable, although not strictly necessary, to tin the surfaces that will come inside of the seam; the solder will flow more easily and there is more certainty of securing a perfect joint throughout the entire seam than without tinning. After the sheets have been secured, so that they cannot shift or get out of place while soldering, the seam should be closed with the mallet. A proper flux is then applied, and the hot soldering bit *a* is held against the head of the seam, as shown in Fig. 10 (*b*). A 4- or 5-pound copper bit is best for this work. The point rests upon the seam, and a little solder is melted from the

bar *b* and flowed to the point of the bit. As soon as the metal becomes hot enough, the solder will *sweat,* that is, run freely, into the interior of the seam; the manner of its disappearance, or soaking, into the seam will indicate to the experienced eye whether or not the work is being properly performed.

When the temperature of the bit falls to nearly the fusing point of the solder, that is, when the bit is too cold, the solder will not flow into the interior of the seam, but will adhere at the edges only. The result is called *skin soldering,* and should always be avoided. Cold bits should not be worked back and forth over the seam. If the interior is poorly soldered, only a hot bit will cause the solder to flow and spread properly.

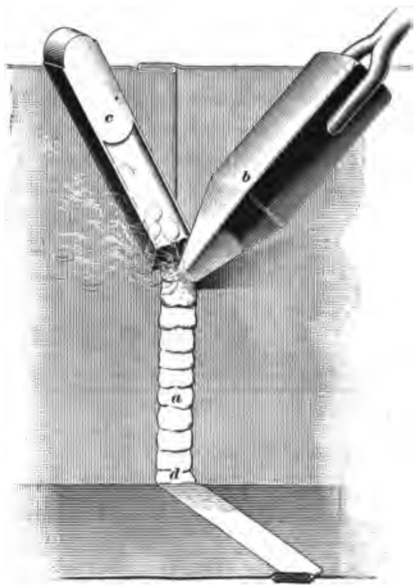


FIG. 11

**20. Soldering Vertical Seams.**—Owing to lack of skill, the beginner finds the soldering of vertical seams a most difficult task, as it seems impossible either to prevent the solder from falling down off the seam or to make it soak in. As vertical seams, in spite of the utmost care, are likely to be skin-soldered—or *skinned,* as the condition is often called for short—they should be avoided whenever possible. If any vertical seam must be soldered in place, the following method is one of the best. After the flat seam is soldered thoroughly, work is begun at the foot of the vertical seam and continued upwards. Solder is melted on the point of a very hot and well-tinned bit and pressed against the seam, with the handle of the copper bit pointing upwards. When the seam has become so hot that the solder

is about to drop from the bit, it is instantly removed and the solder is allowed to set. This operation is repeated, drop by drop, to the end.

The seam, if properly soldered, should resemble that shown at *a*, Fig. 11. This figure also shows the position of the bit *b* and the way in which it is fed by the solder stick *c*. An incompetent mechanic will invariably allow the solder drops to fall and accumulate at *d*, when the vertical seam will be skinned and very weak. To make a strong vertical seam a body of solder must be left on it, as shown.

**21. Soldering a Flat Bead Seam.**—When two comparatively thick sheets of metal, as sheet lead, are to be joined, a bead seam is generally made, as shown in Fig. 12. The edges of the sheets *a* are straightened by rasping or planing, and are afterwards beveled with the shave hook, so that when the sheets are laid as shown, a **V** groove exists between them. The angle of this groove should be sufficient to permit the edge of the hatchet bit to penetrate nearly to the bottom of it. Soil is then applied in a strip about ¾ inch wide along both edges, and on the top and bottom sides of the sheets, as shown at *b*, and should be dried before proceeding to solder. The joint should be laid upon a board; if it rests on a metal surface, the heat will be conducted away, or *robbed*, as it is called, from the edges to be joined, so rapidly that good soldering cannot be done. If the work must be done on a metal surface, two or three layers of thick paper should be laid under the seam.

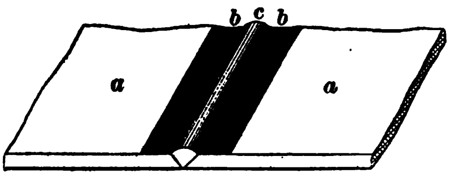


FIG. 12

After the sheets are securely fastened in position, the edges of the joint may be *tacked* together with a drop of solder at intervals of 3 or 6 inches. The hatchet bit, shown enlarged in Fig. 13 (*a*), must be well tinned upon the sides, as at *a*. Solder is fed to the seam by rubbing the end of a bar *b* against the tinned side of the bit, as shown in view (*b*). The groove

is filled with solder during the first operating, and the *floating*, or smoothing and finishing, is performed afterwards as a second operation.

**22.** As there is only a comparatively small margin of difference in the melting points of the solder and the lead, great care must be taken to regulate the temperature of the bit and avoid burning holes in the lead. If the bit is too hot, the work must be touched very lightly and the solder must be fed very rapidly, but as it reaches the lower limit of heat it may be allowed to bear its weight upon the seam and to proceed slowly. The seam should be filled uniformly with solder

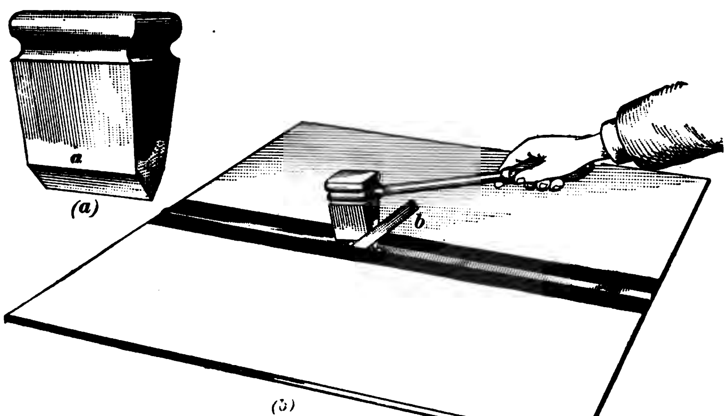



FIG. 13

throughout its length and floated while it is still warm. After the seam is sprinkled with rosin, the hatchet bit is sunk into it and drawn along it steadily, at a speed varying with the heat of the bit. This floating operation levels off the solder, and should leave a smooth and shining beaded seam, as shown at *c*, Fig. 12.

**23. Soldering a Circular Bead Seam.**—Lead pipe is often joined by means of a bead seam. The ends are beveled and are butted solidly together, care being taken that no crevice exists between the ends through which solder can run into the interior of the pipe. The parts are then tacked in position

and the groove is filled with solder, as shown in Fig. 14. The floating is done while the pipe is slowly turned. If the joint

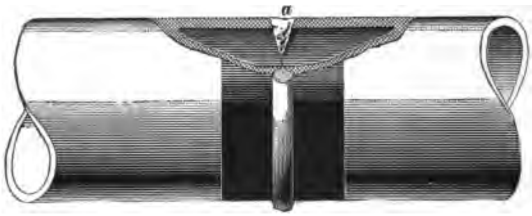
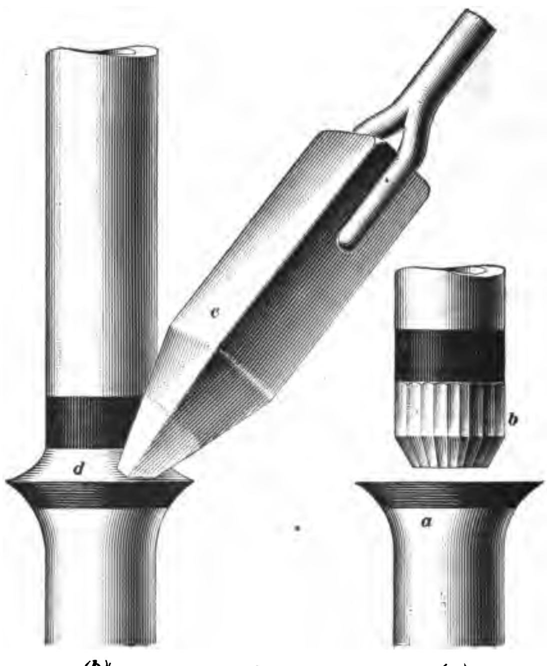



FIG. 14

is not carefully fitted, or if it is burned, the solder is liable to flow inside, as shown at *a*, and will soon be the cause of a chokage should the pipe be used as a waste pipe.




(*b*) FIG. 15 (*a*)

**24.** The cup joint, shown in Fig. 15, is a cheap form of joint for lead pipes. It is suitable only for light pipe that is subjected to little or no pressure.

One end of the pipe is cupped with the turn pin, as shown at *a*, Fig. 15 (*a*), and the other end *b* is shaved and beveled to fit *a*. The fitting must be carefully done, so that no crevice exists between the ends by which solder may be run through to the interior of the pipe. The beveled end must be cleaned to at least ¼ inch above the edge of the cup *a*, and soil should be applied to about ½ inch above the cleaned surface. Powdered rosin is sprinkled in the cup, which is then filled with solder, care being taken to avoid burning either the side of the pipe or the edge of the cup. A little more solder is now heaped on the cup, more rosin is added, and the cup is floated by means of a long pointed bit *c*, as shown in view (*b*). The point is sunk deep in the solder and moved slowly around the cup. The solder should be left smooth, bright, and curved, as shown at *d*. A plumber should not make this kind of joint except where it is unavoidable. A few minutes' difference in time and the pipe can be prepared and the joint wiped, making the joint more substantial.

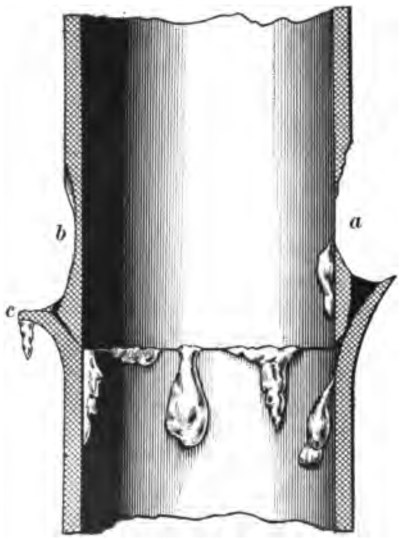


FIG. 16

**25.** Fig. 16 shows a bad job. The fit between the ends was so poor that solder ran through the joint and formed beads and sharp-pointed drops, sometimes called *soldiers*, on the inside of the pipe, which catch lint, hair etc., and thus choke the pipe. A condition of this kind can be avoided where the pipe is large enough to insert the hand. The bottom of the pipe that is inserted into the cup can be beaten into place by the dummy so that there would be no possible chance for the solder to run through. By bearing against the side of the

pipe with the hot bit, a hole has been burned through at *a* and nearly through at *b*, while the edge of the cup has been burned at *c*. This is generally caused by an overheated bit. When soldering a large joint, in order to keep the lead at a proper heat for the fusion of the solder, an extra bit or a small torch would be useful.

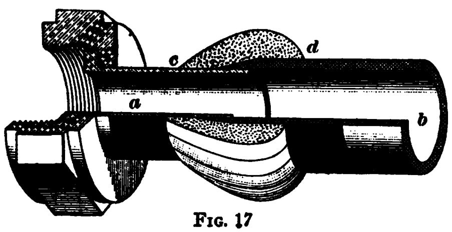


FIG. 17

**26. Soldering an Overcast Joint.**—The overcast joint, shown in Fig. 17, is commonly used to connect a lead pipe to a very short and small nipple or half coupling *a*, as shown. The lead pipe *b* is beveled at the end, and is closely fitted to the brass nipple. The solder is first applied near *c*, and is floated by moving the bit from *c* toward *d*, thereby overcasting the metal upon the lead pipe. The outer surface of the solder will be more or less rough, according to the skill with which the bit is handled. Care must be taken to tin thoroughly the metals to be joined before applying the solder.

**27. Closing Ends.**—When the end of a lead water pipe subject to low pressure—about 50 pounds per square inch or less—must be closed water-tight, the end is usually hammered flat and the edge soldered, as shown in Fig. 18. This finish,

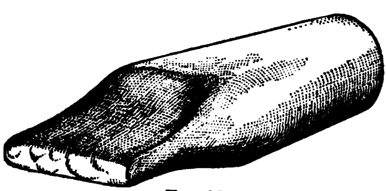


FIG. 18

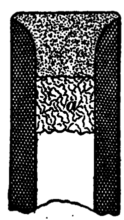


FIG. 19

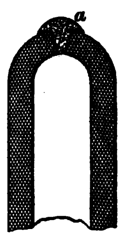


FIG. 20

however, appears rough and should not be used on exposed work. If used on high-pressure work, the flattened surfaces will bulge out; the end will thus crack and leak. When it is

necessary to cut a lead pipe when the pressure is on, the pipe should be flattened as shown in Fig. 18 for a distance of 6 or 8 inches, cut off and doubled back, and again flattened. This will invariably hold back the pressure until the pipe is frozen or the water shut off. If, however, the pipe is to be left in this condition, for example, overnight, a clamp of some kind such as a small flat-jawed vise should be put on to prevent any possible forcing out by the pressure.

Where there is no water to contend with, a better plan is to scrape the inner surface of the pipe a distance equal to about its own diameter and to push a tissue-paper plug *a*, Fig. 19, into the pipe; next, sprinkle some rosin in the end, and then fill it up with solder and sweat it thoroughly with the copper bit,

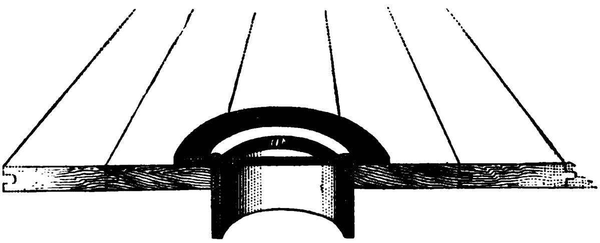


FIG. 21

until it is certain that the solder adheres to the cleaning all the way down to the paper.

**28.** The best way to close the end of a water pipe is shown in Fig. 20. The end is first squared with the rasp, and then hammered in to form a hemisphere. A hole, however, exists at the center, which when soldered over, as shown at *a*, makes the end water-tight.

**29.** Closet bends and other large lead waste pipes that project through the floors of a building before the fixtures are set, can have their ends closed, as shown in Fig. 21, by a flat disk *a* soldered over the opening. This keeps dirt out of the pipes and prepares the ends for the usual water test. But as a flat end on a 4-inch pipe will not resist a heavy pressure, the ends of the bend should be drawn in with the dresser, as

at *a*, Fig. 22, and the point be soldered before securing the pipe in place, when it is known that a heavy pressure test is to be applied. This end is as strong as the pipe itself.

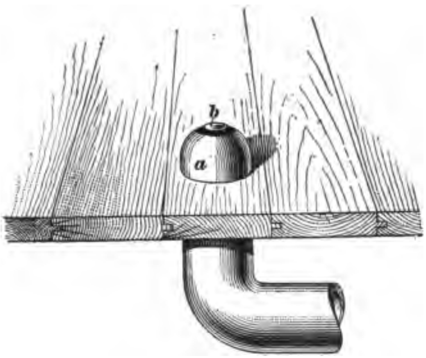


FIG. 22

**30. Soldering Lead Tacks to Pipes.** Lead tacks are soldered with the copper bit to the back of lead pipes, as shown in Fig. 23. The pipe is shaved, that is, scraped with the shave hook, at the parts *a*, and the grooves formed when the tack *b* is placed in position are filled with solder and thoroughly sweated. In soldering on pipe tacks, the bit must be held on the pipe rather than on the tack, in order to heat the pipe properly. Otherwise, the solder will not adhere strongly to the cleaning of the pipe

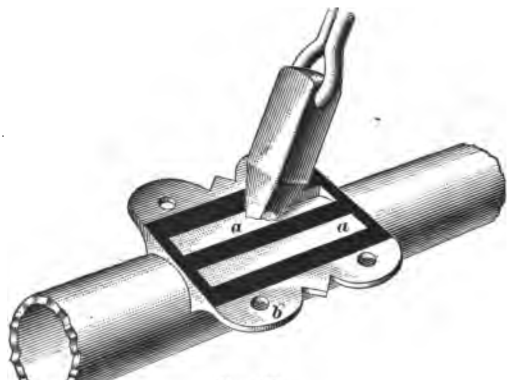


FIG. 23

and the tacks will break away at this place. Tacks must be thoroughly sweated to the pipe, or they are useless.

**31. Repairing Frost Bursts.**—In very cold weather the water contained in lead pipes will often freeze and burst

the pipes. The best method of making the pipe serviceable again is to cut out the burst portion and fit in a new piece of pipe. But in the rush of work that often accompanies very cold weather, it is frequently necessary to make temporary repairs. A section through a frost burst is shown in Fig. 24

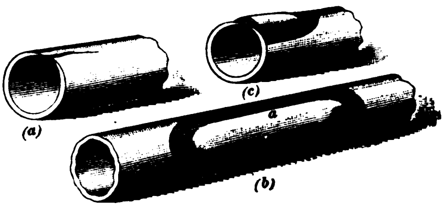


FIG. 24

(*a*). To repair it, the metal around the burst is hammered in to close the opening. The pipe is soiled as far as necessary and shaved to a distance of at least $\frac{3}{8}$ inch all around the split; it is then sprinkled with rosin. The cleaning is now thoroughly tinned and finally soldered over, leaving on a heavy body of solder, as at *a*, view (*b*), to strengthen the pipe against the pressure. A section through the soldered portion is shown in view (*c*). In many cases of this kind a wiped joint is better and is much more serviceable than a solder joint.

**32. Blowpipe Soldering.**—Blowpipe soldering is done chiefly on small tubing and other small articles. The tube is prepared in the same manner as a cup joint. The solder is applied by holding a thin strip of it in the flame close to the joint, so that the molten part will fall into the cup. When the cup is full of solder, it is sweated by heating the joint all around and causing the solder to flow, which makes a clean and strong joint. Care must be taken that the pipes to be joined are perfectly put together; otherwise the solder will run through the joint and into the pipe, causing trouble.

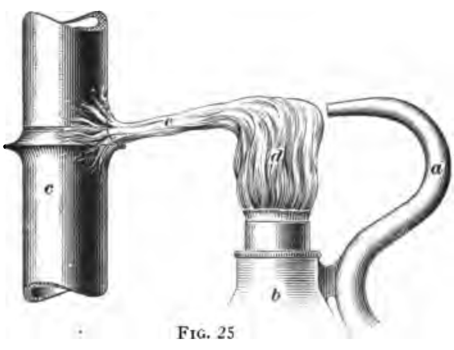


FIG. 25

In Fig. 25 is shown the manner of making a blowpipe joint, in which *a* is the blowpipe blown by the mouth, *b* an alcohol lamp, and *c* the pipe in which the joint is to be made.

By means of the blowpipe the alcohol flame *d* is blown against the sides of the pipe as shown. To obtain the best results, the blowpipe should be held in such a position that the portion *e* of the flame *d* when blown against the pipe will be noiseless. The wind pressure should be steady and its point of application to the flame should be constant. This manner of soldering is best adapted for thin tubes of block tin or tin alloys whose temperature of fusion is low, as the heat can be applied to the pipe or to the solder at will. The pipe can be uniformly heated to the fusion point of the solder with little danger of burning it. Care must be taken to keep the flame shifting about so as to avoid too much heat at one spot, or ugly holes may result.

**33. Soldering Aluminum.**—All copper and tin alloys, and, in fact, most metals, have oxides that can readily be dissolved in some flux, thus leaving the surface of the metal clean, so that the solder may adhere to it. The oxide of aluminum, however, is not soluble in any known flux; hence, the surface must be covered with the melted solder and the oxide rubbed off with the point of the copper bit. In this case, the bit need not be tinned, but should be rather heavy, so that it will hold a large amount of heat. A good solder for aluminum has the following composition:

| | |
|---|---|
| Aluminum | 1 part |
| Phosphor tin | 1 part |
| Zinc | 11 parts |
| Tin | 29 parts |

In making the solder, the aluminum should be melted first; the zinc should then be added in small pieces, taking care not to solidify the melted aluminum. The tin should then be added in the same way, and last of all, the phosphor tin and the mixture thoroughly stirred with a brass rod. This solder should be made in a graphite crucible. The reason for melting in the order given is that, if the metals with the lower

melting points were heated to the melting point of aluminum, they would be partly vaporized, thus destroying the proper proportion of the alloy. To solder aluminum the bit is heated to a dull red heat, solder is placed on one of the surfaces to be united, melted with the copper bit, and then the aluminum oxide rubbed from the surface beneath the molten solder until the solder adheres evenly to the entire surface. The surface of the other piece is then treated in the same way, the two pieces placed together, and heated with the copper bit or with a torch until they unite. Aluminum solder can be obtained from solder makers much cheaper than it can be made in small quantities.

**34. Melting Points of Metals.**—The average temperatures at which different metals melt, which temperatures are said to be the melting points and also the fusing points, are

**TABLE I**

**MELTING POINTS OF METALS**

| Metal | Temperature Degrees F. | Metal | Temperature Degrees F. |
|---|---|---|---|
| Cast iron | 2,192 | Zinc | 680 |
| Copper | 2,100 | Lead | 626 |
| Silver | 1,800 | Bismuth | 505 |
| Brass, common | 1,900 | Tin | 446 |
| Antimony | 1,000 | Sulphur | 228 |

given in Table I. The fusing point varies with the purity of the metal, and the fusing points of alloys vary according to their composition.

## BRAZING

### TOOLS AND SUPPLIES

**35.** **Brazing** is a process of joining two or more metals by hard solder, which has a temperature of fusion much higher than that of soft solders, as well as greater tenacity. Hard solders are composed of alloys of copper, zinc, tin, silver, etc. Only metals having a temperature of fusion exceeding that of hard solders, such as iron, copper, and brass, can be brazed. In this class of soldering the temperature required to fuse the solder is so high that soldering bits cannot be used.

The heat is usually applied to the parts to be brazed by means of an intensely hot blowpipe flame. Small articles may be brazed with a mouth blowpipe, but the sizes of pipe usually handled by plumbers require a compound blowpipe, which uses common illuminating gas for fuel and is blown

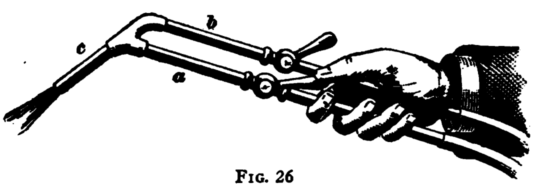



Fig. 26

by a blast of air from a bellows. Larger jobs, having a considerable weight of metal to be heated, are executed in a forge fire. For brazing collars, etc., upon 2- or 3-inch tubing, the fire is arched over with coke, thus making a hot chamber in which the work may be uniformly heated.

**36.** In Fig. 26 is shown a very convenient form of blowpipe to be used in connection with a bellows, which is composed of a gas pipe *a* having a lever-handle controlling cock attached; an air or blast pipe *b*, also having a lever-handle controlling cock attached; and an iron-pipe nozzle *c* joined by a special casting to the pipes *a* and *b*.

**37.** In Fig. 27 is shown a form of blower suitable for supplying air to the blowpipe. It is composed of a single-acting

bellows having an air-inlet check-valve situated on the inside of the bottom board *a*, and another on the upper side of the pressure board *b* and within the rubber storage bag *c*, which is enclosed by a network to prevent its being inflated too much.

The bellows are operated as follows: The top board, hinged at the lower end and supported by a spring within the bellows, on being pushed down with the foot compresses the air within the bellows and forces a portion of it through the upper check-valve into the rubber bag. When the weight of the foot is relieved from the pressure board, the bellows will be again filled with air by the spring raising the pressure board. The pressure of the foot of the workman, being repeatedly applied to the pressure board, will in this manner fill the rubber bag with compressed air, which flows to the blowpipe through the rubber tube *d* when the air cock at the blowpipe is open. The elasticity of the rubber bag serves to equalize the pressure of the blast. This form of blower is capable of furnishing a strong and nearly continuous blast through a jet $\frac{1}{4}$ inch in diameter.

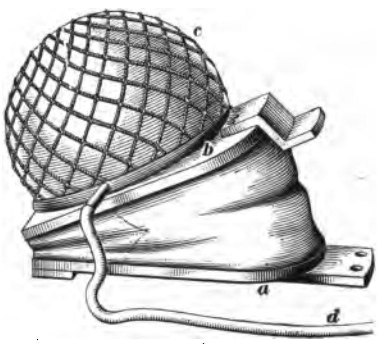


FIG. 27

**38.** The blowpipe should be connected by rubber tubing to a gas burner or other supply and to the blower, care being taken that the bore of the tubing is large enough to avoid excessive friction.

Air is mixed with the gas before it is consumed for several reasons, but chiefly because an all-gas flame is low in temperature and gives off products of combustion that not only tarnish the metal, but also cover it with a coating that separates the flame from the metal being heated.

The gas should be turned on first and should be lit at the jet; air is then admitted gradually until the flame is brought to the proper size and color. If too much gas is admitted

the flame will be yellow and will blacken the work by depositing a film of carbon upon it. If too much air is admitted, the flame will be short, ragged, and noisy, and the temperature will be too low to heat the metal properly. The flame is at its greatest heat and best condition when it burns with a pale-blue or bluish-green color, with no white or yellow parts. Where there is a large amount of brazing or blowpipe work to be done, air furnished from a compressed-air tank would probably be more suitable for the purpose.

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### THE OPERATION OF BRAZING

**39.** The articles to be brazed must be thoroughly cleaned and brightened, either by filing, grinding, scraping, or rubbing with emery paper. They should next be nicely fitted and well supported, and the seam should be well bound together with iron wire to prevent the edges from warping out of place when heated. Spelter or hard solder is placed over the seam in such a manner that when it fuses it will flow, by gravity, into the seam. Powdered borax is then sprinkled over the seam for a flux, and the blowpipe flame is applied chiefly upon the thick parts of the metal at first, the idea being to heat the mass uniformly to the temperature of fusion of the spelter.

The heat of the metal is then increased, care being taken to avoid giving much more heat to the spelter, otherwise it may be burned or spoiled. As soon as the metal is hot enough, the borax will fuse and flow over the parts; and as the heat rises a little higher, the spelter will melt and flow into the crevice and adhere to the faces of the joint. The spelter will sweat into a crevice for a considerable distance, if the metal is clean and is hot enough.

**40.** The melting points of the spelter and of the metal to which it is applied may not differ more than 300° or 400°; consequently, great care must be exercised to avoid overheating the metal. The heat must be applied uniformly, otherwise the work is liable to warp; and if the flame is directed upon one spot too long, a hole is likely to be burned at that

point. When brazing metals that have a low melting point, the blowpipe flame should be withdrawn as soon as the spelter flows.

Sometimes the composition of brass tubing and sheet brass is so uneven, or they are so contaminated by chemical impurities, that brazing cannot be satisfactorily performed upon them. Such material may be used, however, for jobs that require only soft soldering.

Brass tubing is very brittle when hot; consequently, it should not be moved until it has cooled. The process of brazing softens the parts that are heated, and these do not resume their original hardness on cooling.

**41.** Small articles may be heated in a charcoal fire without the blowpipe. A blast may be used to urge the fire, if needed. Large or heavy jobs may be heated in a forge fire, for which clean coke free from sulphur is commonly used. To braze successfully, three things are required: a proper degree of heat, neither too low nor too high; uniform heating, and proper fluxing. When selecting the spelter to be used, that which will melt at a temperature lower than the melting point of the metal to be brazed, must be chosen. When brazing pieces to brass tubes that are made with a brazed seam, it is unsafe to use spelter, because of the liability of opening the seam. A more fusible solder, such as silver solder, should be used.

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### KINDS OF JOINTS

**42.** In Fig. 28 are shown a number of joints suitable for different jobs. The joint shown in Fig. 28 (*a*) is called a *butt joint;* the lumps of spelter at *a* are placed in position ready for fusion. The strength of this joint is small, being in proportion to the actual area of the edges that are united by the spelter. The strength is greatly increased by lapping the plates, as in view (*b*). An equal amount of strength may be secured and the appearance greatly improved by beveling, or splaying, the edges, as in view (*c*), provided the plates are thick enough to permit the beveling to be extended to a suffi-

cient width. The strongest joint for sheet metals is made by dovetailing the edges together before brazing, as in view (*d*).

Thin tubing may be joined by a slip joint, as shown in (*e*), by first annealing one of the ends and forming it into a socket. The end is flared out by means of a drift plug, care being taken not to split the pipe, after which the metal is expanded by hammering until the other end will enter properly.

Circular butt joints may be strengthened by means of a band put on externally, as in (*f*), or by an internal ferrule as in (*g*).

**43.** A knob brazed to the end of a rod is shown in (*h*). To do this job properly, the spelter must be made to flow into

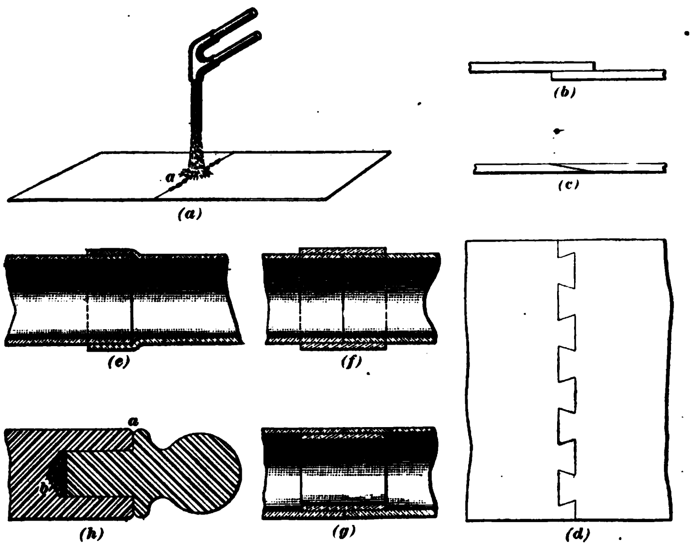


FIG. 28

the socket and secure the shank of the knob. A good job cannot be made by merely securing the edges at *a*. The rod should be held vertically in a charcoal fire until the socket is well heated, at the same time heating the knob. Borax and spelter are then placed in the socket, and as soon as the spelter is melted the shank of the knob should be inserted and pressed into place. The spelter will flow outwards by being displaced

by the shank and will make sure of filling the entire joint; or the space *b* at the end of the shank may be filled with spelter, as shown, and the knob inserted. If the knob and socket are then heated in an inverted position the spelter in *b* will flow, by gravity, around the shank and sweat down to the rim *a*.

## WIPING

### INTRODUCTION

#### CLASSIFICATION

**44.** In modern construction the use of lead pipe for waste lines and vent lines is rapidly being discontinued and replaced by other materials. The older plumbers were obliged to make the lead traps, bends, waste and sometimes soil pipe from sheet lead, which was and still is used extensively for lining large tanks, roofing, etc. The lead bends, traps, etc., are now cast or drawn, and all the plumber has to do is to put them together by the use of wiping solder.

The general principle involved in the process of joint wiping is that of heating the parts to be joined by the metal employed to join them, and of wiping that metal, otherwise solder, into desirable shapes at the proper places by means of a cloth while the metal is in a plastic condition.

The numerous kinds of wiped joints may be classified as underhand joints, upright joints, and seams. The first and second classes may be subdivided into straight joints, branch joints, and flange joints. The third class may be subdivided into countersunk, raised, and corner seams.

#### GENERAL INSTRUCTIONS

**45.** The process of making joints, which is called *wiping*, is used for joining lead to lead or to brass or copper. In making these joints, the metals to be joined should be heated to a

temperature equal to that of the fusing point of the solder applied. Care should be taken that they are not heated to their own melting point. Proper heat is obtained by gradually pouring melted solder over the parts to be joined. If the solder is too hot, it should be allowed to cool before attempting to use it, otherwise a hole may be burnt through the pipe. The solder usually employed for wiping is composed of two parts of lead to one part of tin and melts at a temperature of about 441°. When used for wiping lead, it should be heated nearly to, but not much over, 626°, which is the fusion point of lead, and which allows a margin of about 185° that is available for heating the metals to be joined. The solder pot should be kept as nearly as possible at that temperature, judging it by the appearance of the molten metal. At this temperature no yellow crust will form on the surface and the metal will not show even the faintest reddish color in a perfectly dark room.

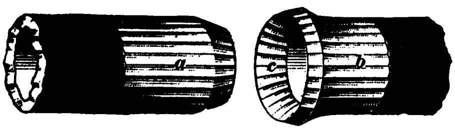


Fig. 29

**46.** In wiping joints on lead pipe the parts to be joined are scribed, soiled, shaved, beveled, and cupped, as shown in Fig. 29. The parts must be carefully fitted together, so that solder cannot run through to the inside of the pipe. To prevent the shaved portions *a* and *b* from tarnishing before wiping, they should be rubbed with mutton tallow, which also forms the flux. The part *c* should also be shaved and greased.

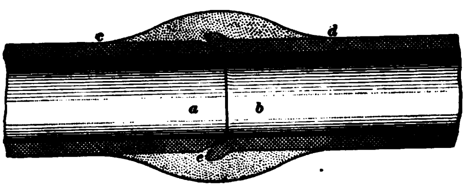


Fig. 30

**47.** Fig. 30 shows a wiped joint in section after the pipes *a* and *b* have been pressed tightly together and a joint wiped over their cleanings. Particular attention should be given to the point marked *e*. The space between the inner, or male, end and the female end, should be noted. It

is a mistake to think that this must be hammered shut to prevent the solder getting into the pipe. If the pipe is fitted properly and held rigidly, it will be perfectly tight, and no solder can get inside. On waste-pipe lines this is not so important, but on pressure work it is important that the cup be left open as shown at *e*. When properly tinned, this point makes the strongest part of the joint, otherwise the joint will last but a short while. The length of the joint, that is, the distance between *c* and *d*, should be about equal to that given in Table II. For pipes larger than 4 inches the joint may be from 3 to 4 inches long, if it is made in a horizontal position. Joints that are made shorter than given in this table are liable

**TABLE II**

**LENGTH OF UNDERHAND WIPED JOINTS**

| Diameter of Pipe Inch | Length of Joint Inches | Diameter of Pipe Inches | Length of Joint Inches | Diameter of Pipe Inches | Length of Joint Inches |
|---|---|---|---|---|---|
| $\frac{1}{2}$ | $2\frac{1}{8}$ | $1\frac{1}{4}$ water | 3 | 2 waste | $2\frac{1}{4}$ |
| $\frac{5}{8}$ | $2\frac{1}{4}$ | $1\frac{1}{4}$ waste | 2 | $2\frac{1}{2}$ waste | $2\frac{1}{2}$ |
| $\frac{3}{4}$ | $2\frac{1}{2}$ | $1\frac{1}{2}$ water | $3\frac{1}{4}$ | 3 waste | $2\frac{1}{2}$ |
| 1 | $2\frac{3}{4}$ | $1\frac{1}{2}$ waste | $2\frac{1}{4}$ | 4 waste | 3 |

to be weak, and those made longer involve a waste of solder. Upright joints on waste pipes usually need not be more than 2 inches long.

The parts should be carefully secured in place, so that they cannot shift while the joint is being wiped. A space of at least 4 inches must be below and on both sides of the joint, to provide room for the movement of the hands and the cloth.

**48.** To make a joint in an ordinary $\frac{3}{4}$-inch lead water pipe, about 10 pounds of solder should be melted in the pot and heated to the proper temperature. The wiping cloths should be warmed until they become pliable, and one is then held in the left hand, steadying it with the thumb, as shown in Fig. 31. The cloth should form a dish, or hollow, to receive and retain

the solder that falls from the joint, in order to heat the under side of it. After the parts that are to receive solder have been rubbed with mutton tallow and securely fastened, the solder in the pot is thoroughly stirred and taken up with a ladle. The solder is then slowly poured over the joint, care being taken to heat the parts uniformly all around. When a quantity of the solder has been caught in the cloth, it should be worked around on to the top; more solder is then poured on this and the surplus caught with the cloth, as before, and the under side heated with it. When the solder on the pipe has become

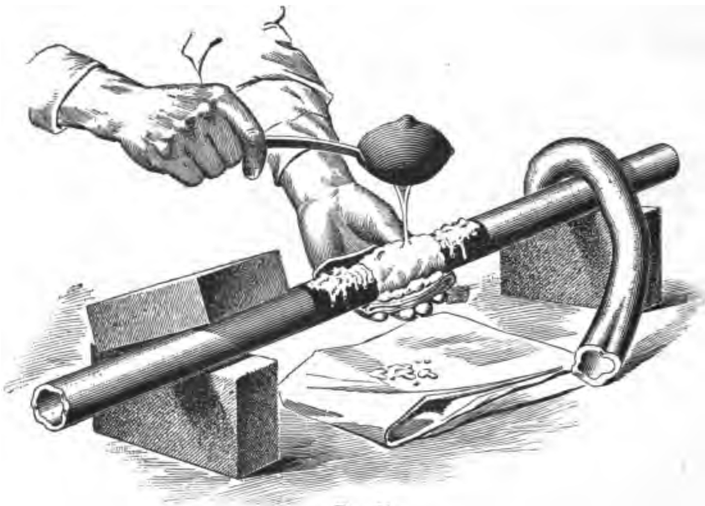

FIG. 31

so hot as to be inclined to slide or drop off, and if it is certain that the surfaces are thoroughly tinned and that the pipe is sufficiently hot to maintain the solder in a plastic condition long enough to perform the necessary work, and also that there is enough solder to make a good joint, pouring should be stopped and the ladle laid down and the other cloth picked up and the wiping begun. The colder pieces of solder that have set, or are beginning to set, are first thrown off the joint; then the edge of the cleaned parts that limit the ends of the joint are found, and the solder is formed into the shape desired, the cloth being hollowed for that purpose. At the time of form-

ing the joint, all the superfluous solder should be thrown off. The extra cloth is very useful for the purpose of forming the joint, and when the joint has been roughly formed, the cloth can be discarded. Many plumbers use but one cloth for the entire operation. The joint is then finished by working the cloth around from bottom to top on both sides, and by finally drawing the cloth tightly across the top. This movement frequently leaves some solder projecting over the soiling, as shown at *a*, Fig. 32, which should be broken off as soon as formed, by lifting it with a knife blade, care being taken not to disturb the joint in any way. It should not be cut off with a knife, for the lead pipe is still quite soft and the blade is very apt to cut into and weaken it.

Some workmen finish wiping with a very quick motion of the cloth, which throws the surplus solder tangentially from

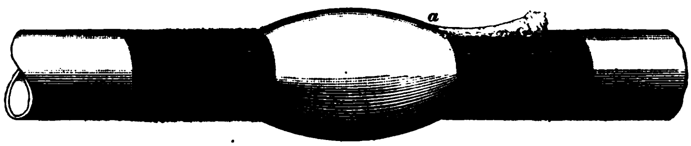


FIG. 32

the joint and leaves the line of finishing hardly visible. This method scatters the solder over the floor, where it picks up impurities.

**49.** When the wiping is completed, the joint should be cooled quickly by blowing a spray of water on it, or by emptying water from a vessel or glass on both ends of joint and then on the joint so as to cool it quickly, because the joint must not be handled until it has cooled. Rapid cooling also chills the surface and prevents the tin from separating from the lead in cooling and settling to the bottom of the joint. It also improves the appearance of the joint by making it bright.

If the joint is allowed to cool off slowly, the tin, the temperature of fusion of which is much lower than that of the lead, will percolate through the joint and fall off the bottom in drops, leaving a coarse, chalk-like, porous joint with a deep hole in the bottom and a long, sharp-pointed teat hanging from

its side like a miniature icicle. The hole in the bottom will finally cause a leak. The liability to overheat the pipe and burn holes in it, increases with the thinness and diameter of the pipe.

## EXAMPLES OF JOINT WIPING

### WIPING AN UNDERHAND JOINT

**50.** The following ten illustrations are taken from photographs of a plumber at work making a plain underhand wiped

FIG. 33

joint on a 1-inch AA pipe. Fig. 33 shows the common way of straightening the end of a lead pipe by the use of the ordinary steel bending pin; but it does not show the evil effects. A

steel bending pin is inserted into the end of the pipe, the point bearing on the middle of the inside of the curve. Force is brought to bear on the pin and the pipe, as shown, and the pipe is straightened in this way. This method, however, sinks the point of the bending pin deep into the lead and damages the pipe greatly, although the damage is not visible on the outside. The best tool to use to straighten a pipe is a piece of iron pipe with the edge filed off. A dummy which has a

Fig. 34

straight end could also be used for the same purpose. The inside of the pipe would not in any way be injured or weakened by the use of either of these tools.

It is a difficult matter to saw a lead pipe perfectly square across; therefore, the end of the pipe must be squared after being cut. The end must be square, so that in preparing the joint the parts will form a neat fit. The end can be cut off

with a knife or squared with a rasp, as shown in Fig. 34. As the rasp cuts deep, the plumber must hold the pipe very steady. Where the pipe in question is part of a house system of supply, care should be taken to prevent the particles of lead from the rasping getting into the pipe. To prevent this, the pipe should be plugged with tissue paper or a small cloth

FIG. 35

which must be removed when the squaring and cleaning has been done.

**51.** Having squared the ends of the pipe, the plumber drives the turn pin into the end of one of the pieces with a hammer, as shown in Fig. 35, thus swaging the end into the form of a funnel mouth. It will be noticed that the pipe does not rest on the bench while the plumber is hammering on

the turn pin. If it did, the force of the blow would bend the pipe and the swaging would not be made central. To prevent the thickness of the pipe around the swage from occupying too much space, it is rasped off to a thin edge or the thick edge can be cut down with the chipping knife and hammer, and finished with the rasp. This saves time, especially when the pipe that is being prepared is extra heavy. The swaged end

FIG. 36

is called the *female end,* and the end of the other piece of pipe, which fits into the swaged end, is called the *male end.* The bevel on the male end should be very neat and true, and the rough tooth marks of the coarse rasp should be smoothed down with a fine rasp. The male end should slip into the female end $\frac{1}{4}$ inch, at least; it must fit closely all around, and be solder-tight, otherwise, molten solder will flow into the pipe

when the joint is being wiped and make what plumbers call a *solid joint.*

**52.** The next part of the work is soiling the ends that are to be joined, as is shown in Fig. 36, the object being to prevent solder from sticking to the pipe where it is not wanted. To make the soil take hold of the pipe, the ends are first rubbed

FIG. 37

with chalk to a distance of 4 or 5 inches. Then the ends are painted with the soil, as shown, and allowed to dry. A preparation known as *plumbers' paste* is also used for this purpose. This paste, which is taking the place of the old-fashioned soil, is in a way a protection to the lead. While in process of wiping, it forms a coating over the pipe where it is put on, and is easily removed by the application of a wet cloth after the joint has been wiped.

**53.** In Fig. 37 the plumber is shaving the male end of the pipe. The female end is set up on a brick so that the soil may be dried by the heat of the fire. The total length of the joint when finished is supposed to be about $2\frac{3}{4}$ inches, and, as the male end slips in $\frac{1}{4}$ inch, the length of the cleaning that the plumber is shaving in Fig. 37 should be $2\frac{3}{4} \div 2 + \frac{1}{4} = 1\frac{5}{8}$ inches. Great care must be taken to avoid skipping any part and leaving streaks uncleaned, for the solder will not adhere to these streaks and they will ultimately become small channels for leakage when the joint is subjected to water pressure. Care must be taken in the shaving so as not to sink the blade of the shave hook into the lead more than is necessary to scrape the surface. A cut around the edge of the cleaning weakens the pipe and makes it liable to break if a bend would have to be made near the joint. After the male end is shaved, the plumber rubs a little tallow or a preparation known as *wiping flux* over the newly cleaned surface to prevent its tarnishing before he is ready to wipe, and also to act as a flux when he is wiping the joint. If there is a fin inside the nose of the male end, it is cut off with a pocket knife or with the blade of the shave hook. By the time the male end is shaved and greased, the female end is dry, so the plumber proceeds to clean it in the same way, making it only $1\frac{3}{8}$ inches long, instead of $1\frac{5}{8}$ inches. The edge of the female end is thus brought in the center of the exposed total cleaning and hence in the center of the proposed joint. After the female end is shaved and shines all around, the plumber places the shave hook inside the swaged opening and deftly whisks it about once or twice, thus cleaning the cup to a depth of about $\frac{1}{4}$ inch all around. This process allows the solder to sweat into the cup to the extreme tip of the male end. The female end and the inside cleaning are now greased, and the two ends are ready to be joined together by a wiped joint.

**54.** To facilitate wiping, the plumber places four bricks as shown in Fig. 38. The two pieces of pipe are laid on a straight line on these bricks in such a way that each piece is supported by two bricks, which of course brings the joint

somewhere about midway between the two inner bricks. The object of placing the bricks on edge is to allow a space of 4 inches under the joint, which is plenty of room for an ordinary hand. If the bricks are laid flat, there would be a space of only 2 inches under the joint, which is too small. Common bricks are 8 in.×4 in.×2 in.

**55.** After the pipes are lined up true, and the cleaned ends are pressed together so tightly that they form an almost water-

FIG. 38

tight connection without solder, the plumber fastens the pipe so there will be no movement or vibration. Experienced plumbers always make their joints perfectly rigid, and when they are wiped they rarely leak. In order to suggest means of fastening the pieces of pipe, two methods are illustrated in Fig. 38. After the plumber underpinned the bricks with slivers of wood to prevent rocking, the pipe next to his gasoline fire-pot was

weighted with a piece of old lead water pipe weighing about 8 pounds and an old lead-pot piece of about the same weight. The two made a load of about 16 pounds, which is quite sufficient to hold that pipe steady, provided it is kept from rolling on the bricks by a rasp or file wedged in at each side. The other pipe, however, was steadied by pouring two bands of solder over it in such a manner that the abutments of these two little bridges might bear on the two bricks at the left, as shown. This method is a quick, lazy, inefficient plan of fixing, which nearly always injures the pipe when the bands are removed. The better way, especially for shop and bench work, is to make or buy a set of clamps adapted for holding pipes for joint wiping.

**56.** After the pipe to be joined has been carefully fastened so that it will not move, the plumber places a piece of cardboard or newspaper under the joint, to catch the surplus solder. When the wiping cloths are warm and pliable, he takes the ladle and stirs up the solder and skims off any dirt that may be on the surface. If this is not done, the fine particles of dirt may be wiped into the joint, thus making it porous and liable to leak. A little of this solder is then poured on a brick having a smooth, level surface, producing a disk of molten solder about the size of a silver dollar, which shines like mercury until it begins to set, when it assumes a whitish steel-gray color. But on the surface and surrounded by this color are some four or five small, silver-like spots about $\frac{1}{8}$ inch in diameter, which indicate that the solder is good.

**57.** When all is ready and the wiping cloths warm, the plumber commences to pour on the solder, using the ladle and wiping cloth, as shown in Fig. 38. Lead melts at about 626° F., and the solder in his ladle is probably at about 800° F., so he must be very careful or he will melt a hole through the pipe and fill the bore with solder. To avoid this, he moves his ladle to and fro along the pipe and slowly pours the hot metal on the soiling as well as on the cleaning. In this way he does not pour twice on the same spot before the heat in that spot is absorbed by the pipe. As he continues to pour on top, some

surplus metal runs over the sides and falls on the newspaper, which keeps it from contact with the dirty bench. But his left hand holds the wiping cloth under the joint. This cloth catches some falling solder, which he occasionally pushes up against the under side and around the joint to warm and tin the surface of the cleaned parts. The plumber should hollow his cloth in the shape of a saucer, so that the molten metal will

FIG. 39

remain in it. Care must be taken that the solder does not run back into the hollow of the hand. If it does a bad burn will result.

**58.** Two prime objects are aimed at in pouring metal on a joint: one is to heat properly the joint and thoroughly tin all the cleaned surface before beginning to wipe for a finish; and the other is to melt enough metal with which to form and

finish properly. The plumber, therefore, is compelled to lift up the surplus metal periodically and place it on the top, as shown in Fig. 39; otherwise, the top would soon be bare and overheated, while the bottom would be overloaded with cold solder. This action rubs the plastic metal against the cleaned surfaces and tins them, besides producing a nearly uniform temperature all over the joint.

Care must be taken not to overheat the pipe. If the pipe gets so hot that the solder will not stay on, the pipe should be

FIG. 40

allowed to cool for a few minutes and the solder tested. If the solder is found to be too fine, a small piece of clean lead should be added to temper it. It is much harder for a beginner to wipe with too fine solder. For that reason, it is good policy to use coarser solder until the operator is more expert in handling the finer quality. After it is certain that everything is right and not too hot, proceed to pour metal on cleaning.

Hurry should be avoided, and while it may take some time and practice to become expert in joint wiping, the time will be well spent.

**59.** When enough heat has been applied to cause the solder to slide down and tend to fall off the joint in spite of the operator, and when there is more than enough metal to form the joint, the plumber immediately lays down the ladle and commences to shape the joint with his cloths. He must move

Fig. 41

his hand quickly, for the metal slides down rapidly and will not wait for him. He must work it up, and at the same time find the edges of the cleaning and form a rough outline of the joint. He must knock off all solder that has set on or near the wiping, so that it will not interrupt his movements. He must guard against the metal falling off the bottom while he is working at the top. In fact, he must look out at the same time for a dozen or more things that are liable to happen during the few seconds he has to wipe the joint after he lays down the heat-giving ladle. Then, when everything is "just so," he

curves the cloth and swings it around the joint—first one way, then the other, as shown in Fig. 40. Before one can realize that the joint is now formed, he draws his cloth neatly over the top, as shown in Fig. 41, to remove any mark left by the swing. With a sharp twitch of the cloth all surplus material is whisked neatly off, and the joint is finished.

**60.** After making the cross-draw shown in Fig. 41, he seizes a looking glass, holds it under the joint to see how it looks on the bottom, and at the same time blows a strong, fine spray of water all over the joint, as shown in Fig. 42, before a single drop of tin has had time to form at the bottom. This

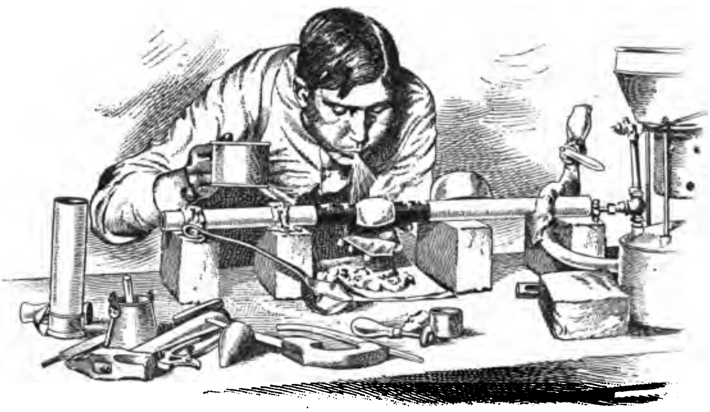

Fig. 42

spray rapidly chills the joint and instantly solidifies its outer surface. The wiping of the joint is now finished, but it must be allowed to cool for a few minutes before it is disturbed; otherwise, it may crack or break apart, and the whole operation would have to be repeated. The joint should be made with the first heat if possible, unless a person is wiping for practice. The first heat is always the best. The longer you work on wiping a joint, the hotter the pipe gets and the harder it is to make a perfect joint. If the pipe gets so hot that you cannot get the solder to adhere to it, a wet cloth should be put on either end to cool it off before proceeding further. Care must be taken in returning the solder to the pot. If it is

wet it should be dried before throwing it into the molten solder, otherwise the moisture may cause a spattering of the metal and injure somebody. Fig. 43 shows the correct form

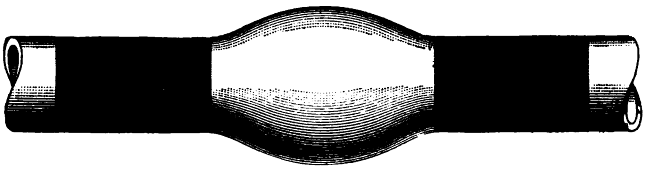

FIG. 43

of a well-made joint. It is uniform in thickness all around. There is neither too much nor too little solder on the joint at any place. A good thickness is over the middle of the joint and the solder tapers neatly down to the edge of the cleaning. No solder overlaps the soil and no part of the cleaning is exposed.

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### WIPING A CONCEALED JOINT

**61.** In Fig. 44 is shown the manner of wiping a joint in a concealed place, the joint in the pipe being out of the sight of the workman. This is done by placing a candle *a* or an

FIG. 44

electric or flash light so as to illuminate the back of the pipe *b*, and two mirrors *c* and *d* so as to reflect the image of the pipe. If a candle must be used great care should be taken to guard

against fire. The formation of the joint must be governed mainly by the feeling of the solder while working.

Care must be taken in doing this kind of work to spread the solder well over the soiled parts of the pipe, as otherwise a hole may be burned through the top of the joint. Solder will then enter the pipe, as shown at *e*. Paper should be spread underneath the pipe to catch the surplus solder that is sure to fall off in such work, as shown at *f*.

**62.** Joints in large horizontal pipes may be wiped in several heats, or two men may operate simultaneously, one on each side. The open ends of the pipe are first closed to prevent a draft of air through it, which would convey heat from the joint to the outer atmosphere. Molten solder is then carefully poured on the shaved ends until enough of the metal adheres to form the joint. The temperature of the pipe near the joint and the solder on it is then raised to the melting point of the solder by a gasoline torch. The torch flame is then suddenly withdrawn, and the now plastic solder is easily formed into the proper shape. Should the solder begin to set before the joint is entirely wiped, more heat can be applied by the torch. Joints over 4 inches in diameter are seldom found in modern house plumbing.

FIG. 45

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### WIPING BRANCH JOINTS

**63. Wiping a T Branch Joint.**—The manner of making a common T branch joint is shown in Figs. 45 to 54. A hole should first be bored in the main pipe with the tap borer, as shown in Fig. 45, care being taken not to pierce the opposite side

of the pipe with the point of the tool. The hole should be much smaller than the branch pipe. The edge of the hole is then

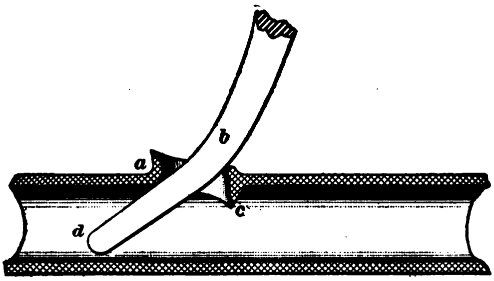



FIG. 46

turned outwards, as at *a*, Fig. 46, with a bending pin *b*, care being taken not to form an edge *c* projecting inwards. The edge should not be turned out by resting the end of the bending pin on the bottom of the pipe at *d*. The edge forced out this way would make a depression and weaken the pipe. A hammer or chisel should be used on the bending pin and the edge worked up gradually. The outwardly turned edge should then be shaped with the turn pin into a cup to receive the end of

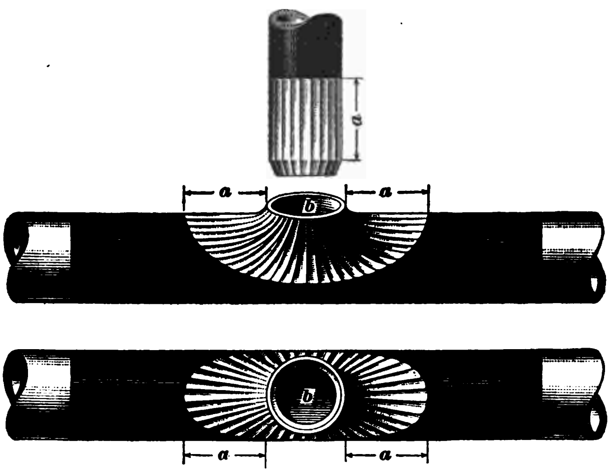


FIG. 47

the branch pipe, which should be beveled and shaved as for an ordinary straight joint, as shown in Fig. 47. This figure

also shows the proper form of the cleaning. In describing the boundary line of the cleaning, it is customary to make the distance *a* from $\frac{3}{4}$ inch to 1 inch on ordinary pipes. The inside of the cupping *b* should be shaved about $\frac{1}{8}$ inch down. If possible, clamps should be used to draw the joint together.

**64.** To wipe a horizontal branch joint, proceed as in the case of a plain underhand joint, but finish it at the bottom instead of at the top. The surplus solder on the branch can be worked to the bottom or the top and wiped off. The finish-

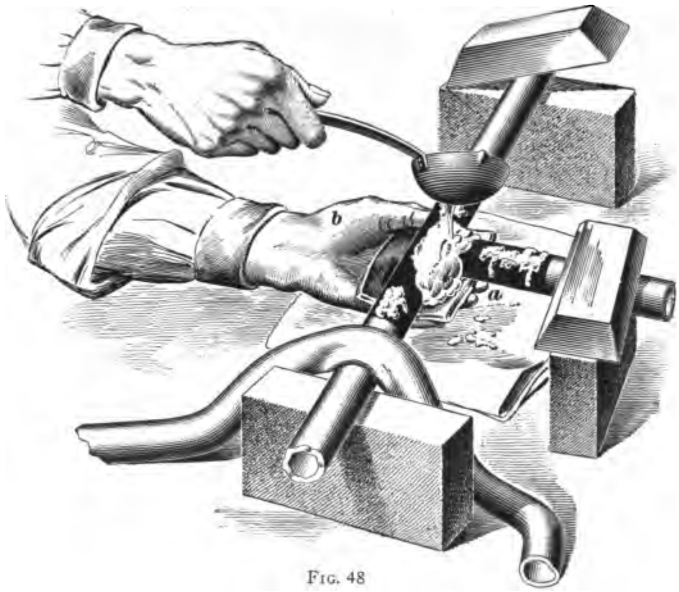



FIG. 48

ing is done by drawing the cloth from *a* toward *b*, as shown in Fig. 48, and then immediately cooling the joint with a fine spray.

The proper form of a well-shaped branch joint on a lead water pipe is shown in Fig. 49. As an inspection of the illustration reveals, the solder is placed so as to give strength to the joint.

**65.** In Fig. 50 are given two sections of a branch joint in which the correct and incorrect forms of preparing and wiping

these joints are shown. At *a* the cup in the lead pipe projects too far, and the solder is also misplaced, too much of it being

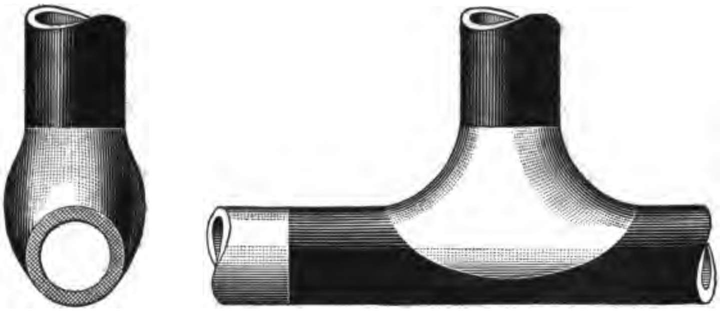


FIG. 49

under the cup, where it is not required, and too little above it. The lead protruding through the solder weakens this part of the joint. The side *b* shows how the cup should be fitted, and the form of the solder when finished. At *c* too much solder is applied, and, consequently, some of it is wasted. This form of wiping indicates poor workmanship. The side *d* shows the proper curve that should be given to the solder at this part of the joint; it is stronger than the pipe and has a neat appear-

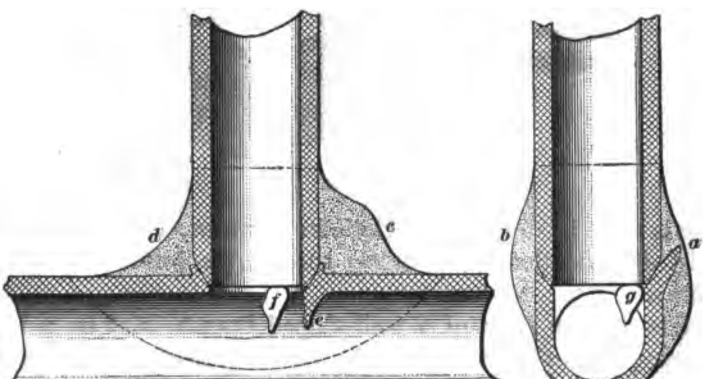



FIG. 50

ance. At *e* is shown the edge of the lead that has been driven into the pipe during the preparation of the joint and that

should have been cut off before the pipes were put together and wiped. At *f* and *g* are shown beads of solder that have flowed inside the pipe through a bad fit in the cup; these defects should be carefully guarded against.

**66. Wiping a Vertical Branch Joint.**—The process of wiping a vertical branch joint is more simple and more sure than that of wiping a horizontal branch joint. After the parts are prepared and fixed rigidly, the main pipe, if small, is raised

FIG. 51

on a small, narrow strip of wood *a*, Fig. 51; molten solder is then splashed on the joint with a splash stick *b*, as shown. It is splashed on gently and in small quantities at first, to avoid burning a hole in the pipe. The speed and quantity is increased, however, and a body of solder is soon piled up against the cleaning. The splashing is continued, or metal may now be poured on the joint from the ladle until the joint is thoroughly and uniformly heated and the mass of solder so soft that it cannot stay up, but slides down on the bench. As

the cold pipe conducts heat away from the parts *c*, the plastic metal must be lifted on to these places to keep them hot. When

FIG. 52

the solder persists in sliding off the parts *c* and when considerably more metal is on the cleaning than is required to finish the joint, the plumber wipes the metal into the proper form, as shown in Fig. 52. A joint of this description is usually

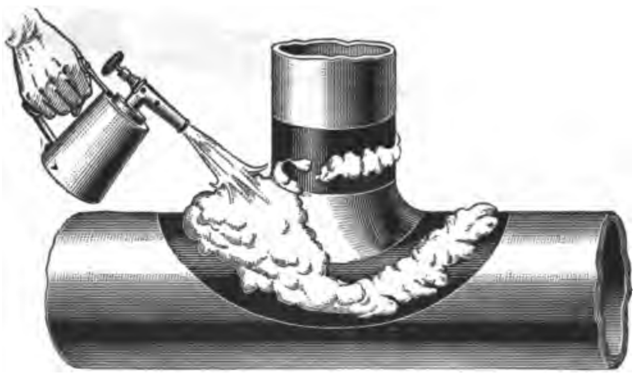
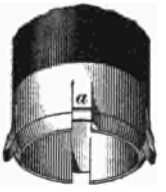


FIG. 53

finished by drawing the cloth down the concave curve *d*, Fig. 50, on to the top of the horizontal pipe.

**67.** On large pipe, if the operator cannot accomplish the wiping before the solder begins to set, a gasoline torch is often used, as shown in Fig. 53, to maintain the proper heat. The torch and the cloth are used alternately, the former to melt the solder and the latter to work it into shape before it sets again.




**68.** The male end of a large branch joint is liable to slip into the opening when the joint is heated. To prevent this, the edge should be slit as at *a*, Fig. 54, in two or more places and these projections driven down outside the cupping, as at *b*, when there is a probability that the weight of the branch may cause it to slip into the horizontal pipe.

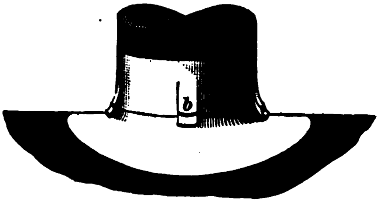



FIG. 54

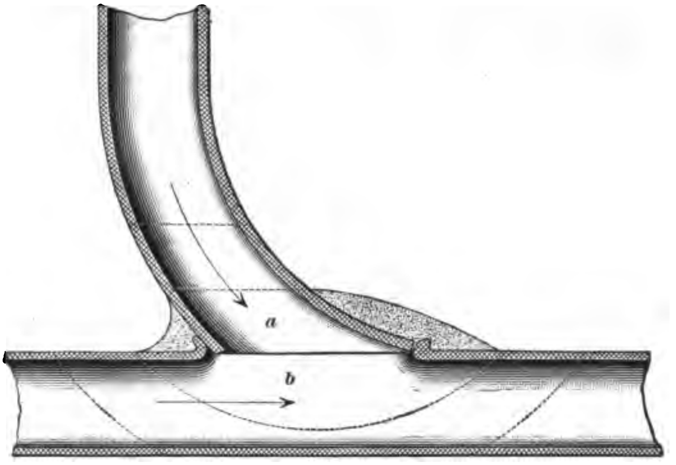



FIG. 55

**69. Wiping a TY Branch Joint.**—In Fig. 55 is shown a TY branch joint. This form of joint should always be wiped

on waste pipes. The arrows show the directions of the flow of the water. A common right-angled branch joint does not permit the waste water to flow away with sufficient freedom. The waste water is apt to back up and leave deposits of grease and refuse that eventually choke the pipe. Joints like this are usually wiped upright, care being taken to fit the pipe *a* so that it cannot slip into *b* while being wiped. In wiping this joint, a most important point is to get up a good heat at the acute angle to the left of the joint. This angle should be wiped first with a small cloth; then a large cloth may be used to wipe the remainder. The opening must be fitted perfectly tight around the branch so that no drops of solder get inside the pipe.

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#### WIPING FLANGE JOINTS

**70.** The flange joints shown in Fig. 56 are made by flanging the end of the lower section of pipe over the board *a*. The upper section is beveled and prepared as for an ordinary joint. The solder is applied with the ladle and is wiped to the shape

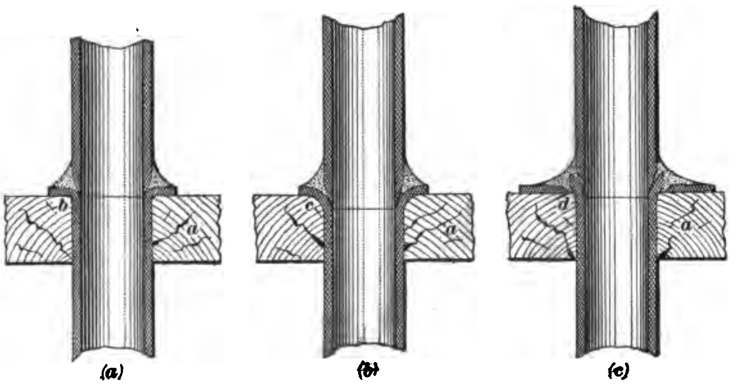


FIG. 56

shown with a thick cloth. The section (*a*) shows a square corner at *b* that should be avoided; the corner should be rounded, as shown in (*b*) at *c*. When a heavy weight is to be borne by the flange, it should be reinforced by means of a lead ring or flange *d*, as shown in view (*c*). This ring should

be shaved on the top and soiled on the outer edge and bottom, and must be laid on the board before the pipe is flanged over. Care must be taken that the flanged part of the pipe is thoroughly tinned before proceeding to wipe. When making flanged joints against finished walls or on floors, the woodwork should be protected by sheets of thick paper, as otherwise the hot solder will scorch or disfigure the woodwork. The flanges of sections (*a*) and (*b*) are liable to be thinned too much or even split in flanging them over on the board, and for this reason these joints are usually made too narrow. When a separate flange or ring, as shown in view (*c*), is used, a wider and much neater joint is obtained. Only this latter form of flange joint should be used.

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### MISCELLANEOUS EXAMPLES OF WIPING

**71. Wiping a Ferrule to a Bend.**—A 4-inch brass ferrule is usually wiped on the end of a 4-inch lead closet bend, the wiping being done on the bench with the work held vertically; 2- and 3-inch ferrules are more commonly wiped in a horizontal position. To prepare a 4-inch lead bend for being wiped on a straight brass ferrule, the ferrule *a* is laid alongside of the bend, as shown in Fig. 57, allowing for the end of the bend to project fully 1 inch into the ferrule. The rings *b* and *c* are then scribed around the bend, *b* being ½ inch below and *c* 1 inch above the end of the ferrule. The space between *b* and *c* is then shaved clean and the part between *c* and *d* is coated with soil. This distance is about 3 inches. The cleaning is then greased with mutton tallow to prevent oxidation, and the ferrule *a* is slipped over the end of the bend, like a sleeve, and the head is beaten into position with the dummy until it fits the ferrule perfectly. The ferrule is now held in such

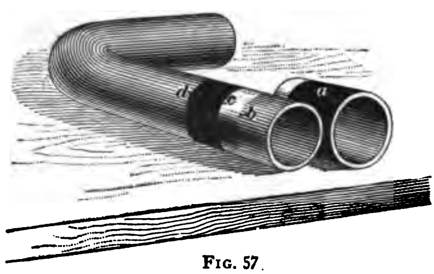

FIG. 57

a position that the width of the exposed cleaning on the lead bend plus the width of the exposed part of the tinning on the ferrule is about 2 inches. If the lead bend is long enough to go entirely through the ferrule it is not necessary to cut it off. It can be flanged over the end of the ferrule and will hold it firmly for wiping. Block the upper opening of bend with cloth or oakum. This will retain the heat in the lead and make it easier and quicker to wipe. The joint is now ready for wiping.

It is not as necessary to have the joint rigidly secured as it is with many other forms of joints, because there is no dan-


Fig. 58

ger of cracking the joint if the pipe should be moved during the process of wiping, or even after it is wiped and before the solder has become hard.

**72.** The molten solder is usually poured on this joint direct from the ladle. but if its temperature is higher than, say, 650° F., it is advisable to commence by splashing the metal on the cleaning with a splash stick or by letting the solder drop on the wiping and thence to the cleaning. At a temperature of 650° F., molten solder will have a very dull red color just visible in a perfectly dark room, and which will just char a

dry pine stick without igniting it. When sufficient metal has been splashed on to cover the cleaning entirely, the heat may be gotten up by pouring the remainder from the ladle. When the heat is up, that is to say, when the ferrule and the lead bend are so hot that the metal slides off the cleaning, the plumber takes the wiping cloth in his left hand, draws up the plastic solder so as to obtain a good body on the joint, and then begins to wipe.

Since the top of the joint usually sets before the bottom, it is customary to wipe all around the top edge first, then all around the bottom edge, finishing as shown in Fig. 58. Care should be taken not to leave too much solder at *a*, since it will interfere with the calking operation when joining the brass ferrule to an iron drain or soil pipe. The waste solder at *b* should be detached from the work before it becomes set. If it sets before it can be removed, a hot iron may be used to melt it. Paper should be laid under the joint to catch the solder and prevent its being fouled by any foreign matter.

Other ways of securing brass ferrules on lead pipes or bends differ with the shape and size of the ferrule. The method described and illustrated here is recognized as the best when straight cylindrical ferrules are used.

**73. Wiping Upright Joints.**—When wiping large upright joints, the heat may be applied by a round iron, a blowpipe, or a gasoline torch, as circumstances may require. Two or more men may be employed on the same joint at the same time in order to finish it in one heat, or one man may do it in several heats. If it is possible to block up the pipe with oakum or anything that will stop the circulation of air, it will be much easier to retain the heat. If the means at hand for heating the joint are sufficient, there is no more difficulty in wiping large joints than in wiping small ones.

**74.** When joints are to be wiped on upright pipes that are already in position, a collar should be attached temporarily to the pipes directly under the joints, so as to catch the solder and to raise the temperature of that part of the pipe under the joint.

In Fig. 59 is shown a piece of lead pipe with a collar *a* in position, which is supported by a cord *b* tied around the pipe. The collar should be cut to a pattern similar to *c*, so that when it is formed around the pipe, the points *d* can be doubled over and locked together, as at *e*, to prevent its spreading apart when the solder falls into it.

These collars are best made of sheet lead, as this metal is very pliable and has no spring. The inner surface of the collar should be coated with soil to prevent the solder adhering to it. The same collar can be used repeatedly by simply soil-

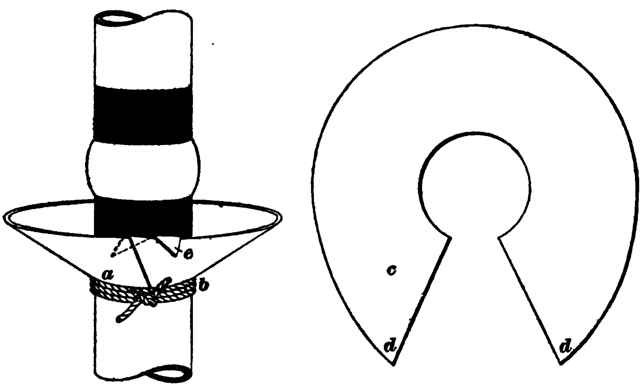


Fig. 59

ing its inner surface on each application. Paper collars are sometimes used, but they are less satisfactory.

**75. Wiping a Cross.**—A *cross*, or *four-way*, is the name given to a combination of two branches wiped to the same pipe and opposite each other, as shown in Fig. 60. The main line *a* is tapped and cupped, as shown in (*a*), to receive the two branches *b*. This joint is wiped in a horizontal position and is as easy to wipe as a common **T** branch, provided that the solder is of the best working quality and that the soiled parts are well heated before the wiping is commenced. The method of preparing the parts is shown in (*a*), while the proper form of the finished joint is shown in (*b*) and (*c*). This combination joint must be wiped with one heat, otherwise the solder will not fuse properly and the joint will probably leak.

FIG. 60

**76.** If the main pipe is much larger than the branches, the latter are wiped separately. If the wipings are quite close together and the molten solder may run on to the joint already wiped, it should be protected with paper pasted over it, as shown at *a*, Fig. 61. This figure also illustrates a simple method of fixing the pipes. The main pipe is fixed down on the bench and prevented from shifting by a pair of dividers *b*. The branch pipe about to be wiped is held steady by a piece of pipe *c* bridging over and resting on its crest. If the pipe at *e* is very heavy and there would be a possibility of its sagging, it should be supported in some way. The top of a box or any suitable raised object may be used to catch the solder so that it will not drop on the floor and splash about while the metal is poured on the joint.

**77. Wiping a Solder Nipple.**—Connections between pipes that are united by solder to other pipes joined by screw

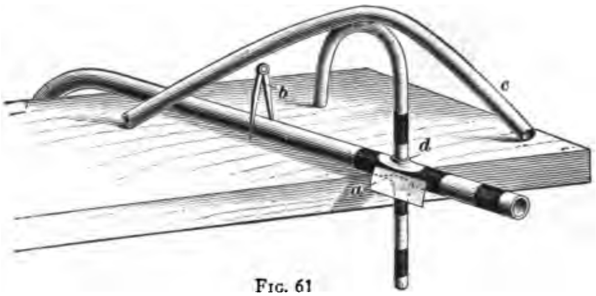


FIG. 61

threads may be made by means of a solder nipple, as shown in Fig. 62. The nipple *a* is made of brass and is joined to the lead pipe *b* by a wiped joint *c*, as shown; the opposite end is provided with an internal or external screw that is adapted to connect with a threaded pipe or to a fitting, as at *d*. A

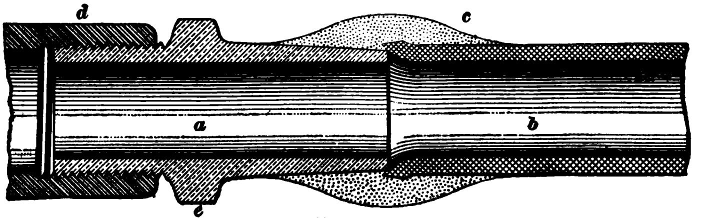


FIG. 62

square or hexagonal shoulder *e* is cast on the nipple to facilitate screwing up. The joint should be wiped before the solder nipple is screwed to the pipe, if possible, because the iron conducts heat away from the nipple too quickly and the solder is liable to set on the nipple before the plumber has time to finish wiping. If such a nipple must be wiped in place, the iron pipe should be heated with a gasoline torch before commencing to wipe the joint.


FIG. 63

**78. Wiping on Trap Screws.**—The work of fitting in the trap screws is done mostly by the trap manufacturers. The traps are received by the

plumber with the ring of the trap screw forced or sweated in. Either of these methods is as good as the wiping or hand soldering. Trap screws should be examined carefully for flaws and proper soldering, and should be resoldered, if necessary, before being put in place. Brass trap screws, or screw-caps, are wiped on lead pipes, traps, etc., by first boring a hole with the top borer and working it up with the bending pin, and then cupping it with the turn pin until it fits the ring *a* of the trap screw, as shown in Fig. 63. The ring being tinned outside, soiled on top and inside the thread, a tissue-paper plug *b* is

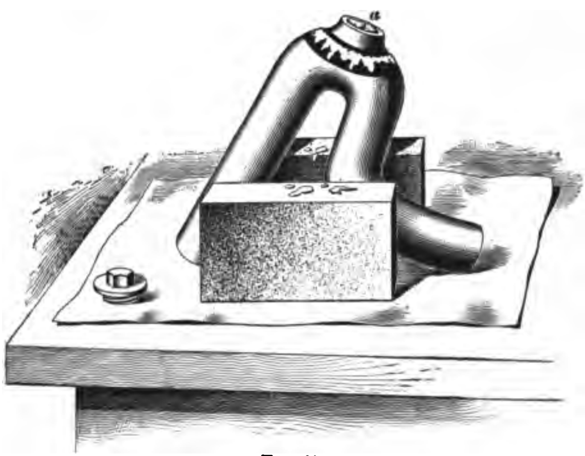


FIG. 64

packed in to close the opening. The lead is then soiled, shaved, and greased. The ring is now tightly driven in so that it will not work loose while being wiped, and yet not far enough to form an obstruction to the flow of water in the pipe. The joint is then wiped.

**79.** Fig. 64 shows a trap held up by two bricks. The trap screw *a* has just been wiped in, and the paper plug is still in position. It should be removed after the loose solder is picked up and remelted. This lapse of time will give the wiped joint an opportunity to set before the paper plug is pulled out.

**HOLDING PIPES WHILE WIPING**

**80.** Fig. 65 illustrates a good method of fixing lead pipes to wipe on a stop-cock. The pipes are laid on bricks and

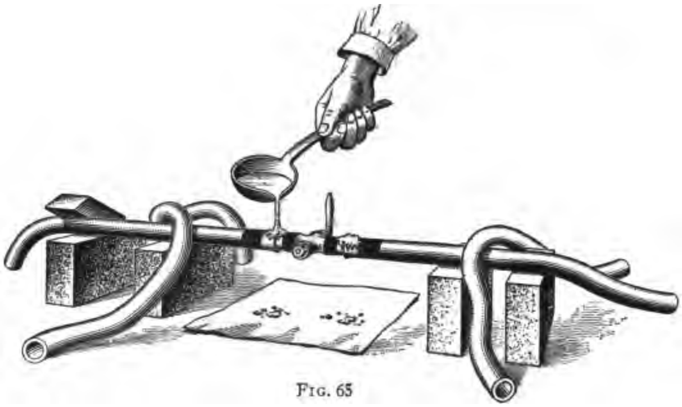

FIG. 65

weighted with pieces of old pipe, solder ingots, or any other convenient heavy bodies. To prevent the cock from turning while the joint is being wiped, melted solder is poured over each joint, as shown. One joint is wiped, and after it has set,

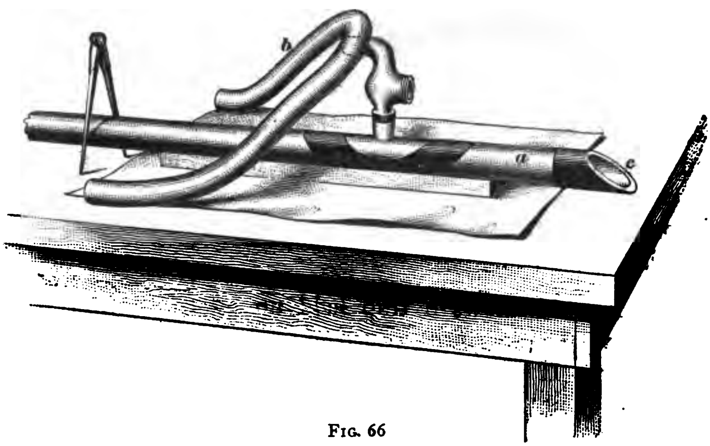


FIG. 66

but before the cock has cooled off, the other joint is also wiped. Straight valves are fixed in the same way. Care must be